

HANDBOOK FOR PREPARATION OF TECHNICAL REPORTS AND OTHER TECHNICAL LITERATURE

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FEBRUARY 1986



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AIR FORCE ENGINEERING & SERVICES CENTER
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EXECUTIVE SUMMARY

This revision incorporates and amplifies recent changes in Form DD 1473 and MIL-STD-847B. In addition, this Handbook includes some guidelines and helpful hints on preparation of technical and scientific literature other than Engineering and Services Laboratory (ESL) technical reports (test plans, statements of work, journal articles, and Air Force publications). This edition also includes more examples of prefaces, covers, DD 1473s, and a revised format for an implementation plan. An appendix containing an open-ended word list has been added for use by project officers and contractors preparing technical literature. In short, although this is not the "end-all" for technical writing, the authors hope the changes will be useful to contractors and project officers alike. Some specific areas of change from ESL-HBK-85-01 are listed below:

1. Only standard outline (numbered) format accepted.
2. Requirements for photographs.
3. Annotated bibliography for writers.
4. RD Form 16 changed to combine Technology Transfer and Implementation Plan.
5. Specific items are keyed to MIL-STD-847B.
6. Changes in distribution statements to reflect revised AFR 80-45.

PREFACE

This Handbook was written to assist HQ AFESC/RD engineers and scientists in the preparation of in-house and contractor-generated technical reports and other documents. This Handbook replaces ESL-HB-85-01, Mar 85.

The instructions in this Handbook are intended to amend and clarify MIL-STD-847B, and are consistent with USAF and Air Force Systems Command (AFSC) R&D directives. Engineering and Services Laboratory (ESL) technical reports document research and development programs, including test and evaluation. Timeliness, accuracy, readability, consistency, and quality cannot be overemphasized. All project officers and their contractors involved in the preparation of technical literature must consider instructions contained in this handbook as minimum acceptability criteria for ESL technical reports.


This handbook implements the requirements of MIL-STD-847B, Format Requirements for Scientific and Technical Reports Prepared by or for the Department of Defense; AFR 6-1, Policies, Procedures and Standards Governing Air Force Printing and Duplicating and Copying; AFR 80-45, Distribution Statements on Technical Documents and Supplements; AFR 110-8, Inventions, Patents, Copyrights, and Trade-marks; and AFSCR 80-20, AFSC Technical Report Program. A condensation of this handbook will be included as a Contract Data Requirements List (CDRL) Appendix to each purchase order contract.


AFESC Project Officer for this handbook was Larry L. Testerman.

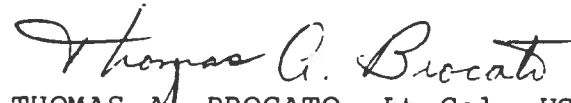
The authors wish to thank Robert W. Day, author of How to Write and Publish a Scientific Paper, for copyright permission to use excerpts from his material in Appendix B of this handbook and Alison K. Stafford and Billie Jean Culpepper for permission to use material from the The Science-Engineering Secretary. Special thanks are also due Gary Taylor of AFESC/RDX for her proofreading and Suzanne Kohlenstein of the BDM Corporation for her perceptive comments.

This handbook has been reviewed by the Public Affairs Office (PA) and is releasable to the general public, including foreign nationals.

This handbook has been reviewed and is approved for publication.


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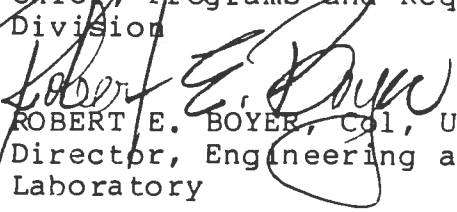

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SECTION I

INTRODUCTION

A. TECHNICAL REPORTS (TRs) (3.1)

A technical report (TR) is defined as "any preliminary or final technical document written for the permanent record to document significant scientific results obtained from, or recommendations made on, Department of Defense-sponsored or co-sponsored scientific and technical activities." This definition applies primarily to research and development, test and evaluation, and is not meant to include staff assistance and operation and maintenance reports. It can, however, include preprints and reprints of theses, dissertations, journal articles and symposium proceedings.

The RDXI Technical Editor will perform preliminary editing and final editorial review of all TRs (both in-house and contract), providing assistance as needed in all stages and preparing final reports for publication after they have been signed by project officers and division chiefs.

This Handbook, with appendices, will assist project officers and contractors in producing readable and consistent camera-ready copy for submission to the Defense Technical Information Center (DTIC).

General guidelines are covered first, followed by preparation instructions. Succeeding sections include a breakdown of the elements of a technical report. Appendix A provides format examples; The Style Guide (Appendix B) includes a list of over-used words and phrases, a format for citations used as references in TRs, a list of abbreviations, and a section on mathematical matter. Appendix D outlines a Technical Report Checklist.

B. THE PROJECT OFFICER'S ROLE

Any organization is best measured by its product. The product of a research and development (R&D) organization is the technical report that documents each research effort. A quality technical report must be timely, accurate, comprehensive, readable, aesthetically pleasing, and produced at minimum cost to the taxpayer. As a project officer, you are the critical factor in meeting these exacting criteria and assuring that the high quality of our laboratory is reflected in the TRs we publish.

You must assure that the final technical report on your research effort meets minimum standards set forth in MIL-STD-847B, as amended by this handbook. Because the handbook adapts MIL-STD-847B to our requirements for consistency and

uniformity, it is no longer enough to tell an author to produce "a technical report in compliance with MILSTD 847B." This could cover a multitude of sins and a diversity of formats and styles, while still complying with the MILSTD.

AFESC Supplement 1 to AFSCR 80-20 states that if AFESC/RD provides 50 percent or more of the funding for a technical effort, we will publish the report. This means that our editing standards apply and that you must assure the format and style standards in this handbook are followed, regardless of whether the technical report is contractor-produced or in-house. It also means that you are responsible for the acceptability of the final product, regardless of funding.

Very few problems exist with efforts funded under routine contracts. A Contract Data Requirements List (CDRL) Appendix, routinely provided as part of the contract process, condenses our handbook into 16 pages and amends specific paragraphs of MIL-STD-847B. This lets the contractor know our requirements from the beginning and holds him accountable for the quality of the final product.

You should be aware, however, that sometimes we fund other agencies to perform the research, through Military Interdepartmental Purchase Request (MIPRs) and other financial documents. This has been done in the past without much of an attempt to clarify exactly what we want in terms of a technical report. This has been costly and time-consuming and resulted in needless effort and expense in trying to produce an acceptable final product. As a project officer, you can avoid this by:

1. Assuring that your funding document (regardless of type) informs the contractor that, if a technical report is required, this report will be prepared according to either the Handbook or the Appendix to the CDRL. (Both are available from RDXI.)

2. Providing the author of the report with a copy of this handbook as soon as you establish contact (preferably even before the first draft is written). If you provide the technical editor with an author's name and address, he will send a copy of the handbook to the author. You should also provide the author with the name and telephone number of the technical editor.

3. Coordinate all phases of producing the report with your technical editor. Live dangerously. Ask questions.

4. Refusing to sign off on documents authorizing payment of contractor until an acceptable camera-ready final is submitted. Remember, it is your responsibility to withhold payment if our criteria are not met.

As a project officer, you should always bear in mind that the Golden Rule (as interpreted by the Wizard of ID) applies: "Them

that's got the gold makes the rules." In a serious vein, as the paying customer, you have every right to demand and expect the highest quality.

C. READABILITY

1. Introduction

Do not overestimate the reader's knowledge of the subject matter. Not all readers will be experts in your field of interest. Write in acceptable English. Your language should be free of cliches, pet phrases, and jargon common to a field of interest. When choosing a word, select it for both meaning and connotation. Redundant and meaningless words and phrases such as "obviously," "it can be seen," or "it should be noted," only increase the complexity of the report and should be avoided. A list of words and phrases that detract from readability is found in Appendix B.

2. Paragraph Phrasing

Make your paragraphs and sentences effective. Long paragraphs discourage the reader and should be avoided. Take time to break into logical but smaller paragraphs. Start each paragraph with a topic sentence. Achieve readability and emphasis by varying the types of sentences used. Do not try to compress a paragraph of information into one sentence by the use of connectives. If a question exists as to technical meaning, make two or more sentences out of the one lengthy sentence. On the other hand, a steady diet of "Dick and Jane writing" (short choppy sentences) can put the reader to sleep and can be avoided by using conjunctions, punctuations and other linking devices to combine simple thoughts into one readable sentence.

3. Spelling and Grammar

Explain esoteric words, acronyms, and expressions with the first usage. Avoid wordy sentences. Unnecessary words can often be eliminated by writing in the active voice.

a. When Air Force nomenclature is used for equipment, use the official nomenclature first. A shortened name or acronym may be used throughout the report if it is explained in a footnote or in parentheses after its first usage. If nonstandard abbreviations or acronyms are used in the text, always spell them out the first time they are used.

b. Spelling must be correct. Carelessness can affect technical accuracy. Some examples are "adsorption" and "absorption" or "principal" and "principle."

c. Be sure pronouns refer clearly to their antecedents. Misuse of "this" and "it" can change or cloud technical meaning.

d. Watch tenses. Generally, the work reported has already been done. Therefore, the past tense is most logical when reporting the activity. Use present tense when a condition, parameter, physical law, etc., is true, exists, or is in effect without regard to the information in the report. Use future tense as conditions of the work and equipment demand reference to the future.

e. Use adjectives instead of a series of nouns as adjectives. Such a series creates clumsy sentences that are hard to understand.

f. Be careful of subject-verb agreement. Confusing the plural object of a preposition with the singular subject of the sentence and, subsequently, choosing a plural verb are frequent and distracting occurrences.

g. Also watch out for pronoun-antecedent agreement. Although you may decide whether to use "The data (facts) are" or "The data (information) is," your decision determines whether the plural "they" or singular "it" will be the referent pronoun. Another common misuse is referring to criteria as "it."

h. Beware of "there is, there are, there was, there were, it is, it was," etc. Most sentences that begin with these overworked phrases can be worded in a simpler, more direct fashion.

i. Avoid Sexist Language. Do not go to some of the ridiculous or stilted extremes now in vogue, but do not use "he" or "men" when referring to tasks that may be performed by both men and women. "The worker," "the person," "the engineer," and "the scientist" are perfectly acceptable, but become awkward when they require singular pronoun referents such as "he/she" or "he or she." It would be preferable to say "persons," "personnel," "scientists," "engineers," etc., and use the simple plural, "they," as the referent.

D. ORGANIZATION

A tightly organized report provides the reader with a patterned progression through the text. Begin with an outline and follow it.

SECTION II

PREPARATION INSTRUCTIONS

A. DRAFTS (5.9.1.3)

Project officers will submit clean, typed, 1 1/2-or double-spaced drafts of in-house or contractor-produced technical reports to AFESC/RDXI for assignment of a TR number and editing. The editor will look for the following:

- Complete, accurate, logical, and technical presentation
- Clear, informative writing
- Clear, uncluttered professional illustrations
- Proper format and organization
- Acceptable grammar and spelling
- Conformance to ESL Style (See Appendix B)
- Possible copyright violations

Single-spaced drafts printed on both sides will not be accepted!
Do not stamp "Draft Copy" over text of draft.

The editor will normally use the following source books when reviewing the draft copy. (See Annotated Bibliography).

Government Printing Office Style Manual

McGraw-Hill Dictionary of Scientific and Technical Terms

Webster's Third New International Dictionary

The Chicago Style Manual

MIL-STD-847B, as amended

Day, Robert, How to Write A Scientific and Technical Paper

Flesch, Rudolph, Look It Up

American Society for Testing and Materials, Standards for Metric Practice

All edited drafts are sent to project officers for review, coordination, and return to author, as necessary.

The technical editor will resolve all technical or editorial questions with the project officer before publication of the report.

The project officer will review contractor-prepared reports for complete and accurate technical content and compliance with contract specification. He will then return an annotated edited/reviewed copy of the draft to the contractor for correction and preparation of the final Camera-Ready Copy (CRC). The project officer should assure that the contractor returns this draft with the CRC.

B. CAMERA-READY COPY (CRC) (5.9.1.2; 5.9.3)

The CRC will be prepared single- or 1 1/2-spaced on one side of white, heavyweight, opaque bond paper or reproducible masters (8 1/2 by 11 inches) suitable for camera and microfiche reproduction. Type face will be either 12-pitch Letter Gothic or Prestige Elite. Neither dot matrix typing nor typesetting is acceptable. Camera-ready copy will include a completed DD Form 1473, Distribution List, RD Form 16, and Preface signed by Project Officer and Division Chief, when submitted to RDXI. After final editorial review, RDXI will obtain Director's signature and forward for printing.

Print must be clear, legible and reproducible.

Calculations and equations should be professionally lettered.

Figures, tables, or inset material must be taped or pasted down around the sides. Use transparent tape. Marking on text should only be done with a nonreproducible pencil.

Delete all extraneous markings such as contractor TR numbers, drawing numbers, and similar contractor identification. The contractor's TR number may be included on the DD Form 1473.

The technical editor will review all incoming CRCs for compliance with these standards. Unsatisfactory CRCs will be returned to the project officer for corrections. If necessary, the technical editor will meet with contractors and/or project officers to resolve problems and provide guidance. Upon completion of publication, all CRCs are returned to the project officer for disposition.

Upon receiving a technical report, the Defense Technical Information Center (DTIC) reduces each report to microfiche and then prints hard copy in response to requests. A report that is barely legible will make a poor quality microfiche, and an unreadable hard copy. Therefore, CRCs submitted for AFESC TRs should

be original print, whenever possible. This includes not only the text, but forms, drawings, schematics, tables, listings, and computer printouts. Photographs should be black and white glossy prints. In cases where reproduction with electrostatic copiers is unavoidable, care must be taken to ensure that a reproducible copy is submitted. When illustrative material is reduced too drastically, or when an extremely small type face is reduced, the characters will not survive the DTIC reduction-reproduction process. Choose a larger page and a larger type face for the originals that must be reduced before printing. In addition, do not tape over characters with heat-sensitive tape, because the tape will melt the characters and produce unsatisfactory copy.

NOTE: Project officers must not sign off on DD Form 250 until RDXI has accepted the CRC for publication.

C. DISTRIBUTION INFORMATION

1. Distribution List

Each project officer must provide Technical Editing with names, office symbols and complete addresses of all agencies who are to receive initial copies of TRs. The project officer then provides an abbreviated distribution list with each camera-ready technical report, indicating only the receiving agency and the number of copies. Only one line entry per agency will be shown, regardless of number of copies. If distribution of the report is limited, the distribution list must be printed as the last page of this report. RDXI will make initial distribution and DTIC will make secondary distribution as requested by Government agencies and authorized contractors.

2. Handling

Initial distribution is handled by Technical Editing. Subsequent requests for TRs are sent to the Defense Technical Information Center, Cameron Station, Alexandria, VA 22314, and may require the originator's approval to release limited distribution reports.

3. Distribution Release Statements

The Cover, Preface and DD Form 1473 for AFESC TRs must display one of the following distribution statements as outlined in AFR 80-45.

a. Distribution Statement A: Approved for public release; distribution is unlimited. All Statement A reports must be cleared by the AFESC/RD Scientific and Technical Information Officer

(STINFO) and approved for public release by the Public Affairs Office (PA). The technical editor will request PA approval for all CRCs before obtaining the ESL Director's signature.

b. Distribution Statement B:

Distribution limited to U.S. Government agencies only; this report documents test and evaluation. Distribution limitation applied (date). Other requests for this document must be referred to the Air Force Engineering and Services Center (AFESC/RDXI) Tyndall Air Force Base, Florida 32403.

Distribution limited to U.S. Government agencies only; this report contains information for operational or administrative use. Distribution limitation applied (date). Other requests for this document must be referred to the Air Force Engineering and Services Center (AFESC/RDXI) Tyndall Air Force Base, Florida 32403.

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c. Distribution Statement C:

Distribution limited to U.S. Government agencies and their contractors; this report documents critical technology. Distribution limitation applied (date). Other requests for this docu-

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d. Distribution Statement D:

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Distribution limited to DOD components only; this report contains information that must be protected from premature dissemination. Distribution limitation applied (date). Other requests for this document must be referred to the Air Force Engineering and Services Center (AFESC/RDXI) Tyndall Air Force Base, Florida 32403.

Distribution limited to DOD components only; this report contains software documentation that can be released only

under provisions of DOD Instruction 7930.2. Distribution limitation applied (date). Other requests for this document must be referred to the Air Force Engineering and Services Center (AFESC/RDXI) Tyndall Air Force Base, Florida 32403.

Distribution limited to DOD components only; this report documents critical technology. Distribution limitation applied (date). Other requests for this document must be referred to the Air Force Engineering and Services Center (AFESC/RDXI) Tyndall Air Force Base, Florida 32403.

Distribution limited to DOD components only; this report contains foreign government information that may be released to foreign nationals only with approval of competent authority. Distribution limitation applied (date). Other requests for this document must be referred to the Air Force Engineering and Services Center (AFESC/RDXI) Tyndall Air Force Base, Florida 32403. (Note: Documents with this statement are normally classified.)

f. Distribution Statement F:

Further dissemination only as directed by the Air Force Engineering and Services Center (AFESC/RDXI) Tyndall Air Force Base, Florida 32403, or higher DOD authority (Note: Documents containing this statement are normally classified.)

g. Distribution Statement X:

Distribution authorized to U.S. Government agencies and private individuals or enterprises eligible to obtain export-controlled technical data in accordance with regulations implementing 10 U.S.C. 140c (date of determination). Other requests must be referred to (insert controlling DOD office).

4. The following notice is required on all documents determined to contain export-controlled technical data.

WARNING. This document contains technical data whose export is restricted by the Arms Export Control Act (Title 22, U.S.C., Sec 2751 et seq.) or Executive Order 12470. Violations of these export laws are subject to severe criminal penalties.

5. All limited distribution technical documents will be marked in the following manner:

a. Classified: DESTRUCTION NOTICE: Destroy in accordance with DOD 5200.22M, Industrial Security Manual, Section II-19 or DOD 5200 I-R, Information Security Program Regulation, Chapter 9.

b. Unclassified: DESTRUCTION NOTICE: Destroy by any method that will prevent disclosure of contents or reconstruction of the document.

6. If this Laboratory publishes a technical report with limited distribution, the agency writing or producing the report (even another DOD laboratory) should be prohibited from publishing this research in their unlimited distribution report. As a project officer, you should consider this in preparing your Statement of Work.

7. Initial distribution of TRs should only include those you know have a legitimate need for the information. Others can buy the reports from Defense Technical Information Center or National Technical Information Service. As a taxpayer and a project officer, you should try to limit your initial distribution list to 75 copies.

8. The project officer determines which statement applies. For other distribution statements not specifically addressed in this handbook, contact the technical editor or the STINFO.

D. TYPING

1. Word division

- ° Break words at the end of a line, according to syllables, using either Webster's Third International Dictionary or Webster's Instant Word Guide. Do not leave words unbroken to the point that a jagged right margin will distract the reader. Of course, right margin justification will solve the problem if you have the capability.
- ° Never carry a divided word over to another page.
- ° Never divide a word of one syllable (Example: sea-rch).
- ° Never separate a single letter or the first two letters from the rest of the word (Examples: a-round, se-lect).
- ° Never carry a two-letter syllable over to the following line (Example: like-ly).

2. Paragraph division

- ° Never divide a paragraph of less than four lines. Type the whole paragraph on one page or the other.
- ° Avoid "widow" lines--one line that starts a paragraph at the bottom of a page or ends a paragraph at the top of a page.

3. Correcting Typing Errors

Use liquid whiteout or adhesive correction tape to correct typing errors on the CRC. Correctible typewriter ribbon (lift-off tape) is acceptable for minor corrections. Do not erase or use chalked paper. Strip in paragraph-size changes or corrections. This applies to project officers who prepare CRC, as well as to RDXI preparation of CRC for publication.

E. NUMBERING SYSTEMS AND NUMBERS (5.9.1.6)

1. Basic Rules

Use Arabic numerals for all numbering systems. Exceptions: Section numbers and volumes, if applicable, will be in upper case Roman numerals, i.e., Section IV, Volume III. Appendices are identified by letter designation; i.e., Appendix A, etc.

Number figures, tables, equations, and references consecutively throughout the main body of the report (Figure 5, Table 7, Equation (3), Reference 1). Include the letter designation with the numbers for these items in appendices. See Section V, paragraph F for details.

2. Page Numbering

Number all pages consecutively in Arabic numerals except for front matter (DD 1473, Summary, Preface, Table of Contents, List of Figures, List of Tables, Glossary, etc.) which will be numbered with lower case Roman numerals. Front matter page numbering will begin with DD Form 1473. The first page of the report itself is number 1. Thus, the succeeding pages are 2, 3, 4, 5, etc., throughout the report. Consecutive numbering will continue through the appendices. Do not combine page numbers with section numbers, appendix numbers, or any other system.

Odd-numbered pages are right-hand pages, and even-numbered pages are left-hand pages. The first page of the Preface, Table of Contents, Section I, and the first page of Appendix A must all start on right-hand pages. When separate title pages are used for Appendices they should start on right-hand page.

Only left-hand (even-numbered) pages may be blank pages. To start a Preface, Table of Contents, Section I, Appendix A, etc., on a right-hand page, write "(The reverse of this page is blank)" under the page number of the preceding right-hand page. This will eliminate the need for a separate master sheet with just a page number on it. Samples are shown in Appendix A.

All page numbers will be centered on line 61.

3. Section and Paragraph Numbering

Start each Section on a new page. Number headings and paragraphs only when needed for clarity. Do not use a decimal numbering system.

F. HEADINGS (5.4.1, 5.4.5, 5.4.6)

Each section will be designated by a sequential upper case Roman numeral and a short caption. The section designation will be centered on the first typing line of the page with the short caption centered on the page, two lines below the section designation line. The text will begin three lines below the caption. Section I will begin at the top of the first available full right-hand page following the front matter. All other sections may begin on either a left- or right-hand page.

Sections, paragraphs, and subparagraphs will be prepared in the traditional outline format as follows: THIS IS THE ONLY FORMAT AUTHORIZED FOR ESL TECHNICAL REPORTS.

SECTION I

FIRST-ORDER HEAD

A. SECOND-ORDER HEAD

1. Third-Order Head

a. Fourth-Order Head

(1) Fifth-Order Head. This normally takes run-in text.

First-, second-, and third-order heads normally stand alone. Fourth- and fifth-order heads can be used with run-in paragraphs, at writer's option.

SECTION III

THE TECHNICAL REPORT

A. ORDER (5.3, 5.4)

Although TRs may not always contain all the following elements, those used must appear in the following order:

Front matter	Front cover Notice Statement Report Documentation Page, DD Form 1473 (Includes abstract) Summary (If needed) Preface Table of Contents List of Figures List of Tables Glossary of Terms (if needed) List of Abbreviations, Acronyms and Symbols (if needed)
Body of Report	Introduction (Section I) Main text (Perhaps several sections) Conclusions Recommendations (If needed)
Reference Material	References (If needed) Bibliography (If needed) Appendices (If needed) Index (If needed)
Other	Distribution List (Except for Distribution A) Back cover or Back Cover with return address (Distribution A)

B. MULTIVOLUMES

A technical report shall not contain more than 175 sheets (350 pages). If a volume requires more than 175 sheets, additional volumes may be used to contain appendices, mathematical analyses, operation instructions, etc.

All volumes of the same TR will carry the identical basic title, and each separate volume will carry an identifying Roman numeral volume number and a distinctive subtitle. Example: ESL-TR-82-XX, Rapid Runway Selection, Volume II: Computer Programmer's Guide.

Specify the volume number and the total number of volumes; i.e., Volume I of III, as part of the subtitle (Block 11, DD Form 1473).

The Abstract of a multiple-volume TR may encompass all the volumes and thus be the same in each volume, or it may be written to cover the material in each volume separately, depending on the nature of the material.

Add a statement at the beginning of Block 19 (Abstract) of DD Form 1473 to include the following type of information:

This technical report is divided into three volumes. Volume I explains the Computer Model for Bomb Damage Repair Times, while Volume II contains the Appendix, and Volume III is the User's Manual.

Treat each volume as a separate document with separate covers, DD Forms 1473, Preface, Table of Contents, and consecutive Arabic numbering systems for pages, figures, tables, etc. A Table of Contents, List of Figures, and List of Tables will be prepared for Volume I and for each subsequent volume, covering that volume only.

C. PARTS

At times, publications exceed the 350-page limit. Although the material is continuous, these publications can be broken into parts.

1. Breakdown

Treat this type of report as one continuous publication with covers separating the parts at approximately every 300 pages.

Start each part at a new section or major paragraph heading when possible.

Be sure each part begins on a new right-hand (odd-numbered page).

2. Front Cover

Identify each part in Arabic numerals on the front cover: Part 1 of 2; Part 2 of 2.

3. DD Form 1473

Add a statement at the beginning of Block 19 (Abstract), to encompass the following type of information:

This report is divided into parts. Part 1 consists of the front matter and text pages 1-252. Part 2 consists of text pages 253-490, Appendixes A and B, and the distribution list.

Place a DD Form 1473 at the beginning of each Part.

Block 1 will reflect the TR number and the particular part number; i.e., AFESC-TR-78-XX, Part 1 (or Part 2 or Part 3, as appropriate).

Block 11 will show the title of the TR and the part number as follows: TITLE, Part 1 of 3 (or Part 2 of 3, etc., as appropriate).

Block 15 will reflect the total number of pages within the covers of the specific part. This will be filled in by the Editor.

All other information on the DD Form 1473 will be the same for all parts.

Each part shall contain a complete DD Form 1473, Preface, Table of Contents, List of Figures, and List of Tables so that it can be handled as a single document.

SECTION IV

FRONT MATTER (5.2, 5.3)

A. RD FORM 16 (IMPLEMENTATION PLAN AND TECHNOLOGY TRANSFER)

RD Form 16 combines the Implementation Plan with the technology transfer information required by Public Law 92-480.

1. Implementation Plan

Although not published as part of the technical report, the Implementation Plan plays a critical role in explaining your documented research to the busy reviewer of your report (Branch Chief, Division Chief, Director, Commander, etc.). For this reason, the following questions must be adequately addressed in each Implementation Plan.

a. Objective: What was the objective of the research?

b. Summary: What was the problem? Why was it there? How did we learn about it? What efforts had been made to solve the problem? With what success? How did we approach it? What did our research produce?

c. Use: Now that we have done the research what is its use? Who will use it? Will be useful to both the military and civilian communities?

d. Action: How will the research be put into use. What technology transfer procedures are necessary?

Because of the levels of review required, the Implementation Plan is much more than just a square-filling exercise. The plan should be a clear, concise, organized summation of your research and should be limited to two pages. An example, with the suggested format, is shown in Appendix A in addition to a checklist.

2. Technology Transfer

RD Form 16 will not be published as part of the report but will inform the branch chief, division chief, RDX, the director and commander of the technology transfer potential of research documented in the technical report. In addition, this assures that technology transfer (required by Public Law) is no longer an after-the-fact consideration.

An example of a completed RD Form 16 is found in Appendix A and may be used as both an Implementation Plan and Technology Transfer

Assessment. Even if the product is not transferable, the form should be completed to show that the issue has been addressed.

B. FRONT COVER (SEE APPENDIX A)

The front cover will be prepared from information on the completed DD Form 1473 provided by the project officer or contractor when the CRC is submitted.

C. NOTICE PAGE

Special notices will be included on the notice page (which will be printed on the inside front cover) and will not be page-numbered. Examples of the different types of notices are included in Appendix A.

D. DD FORM 1473

This form is mandatory and will follow the front cover. Instructions for preparation of this form are indicated on the form and examples of correctly completed DD Form 1473s are found in Appendix A. Both sides of DD 1473 will be numbered (i and ii) even if reverse side is blank.

E. PAGE NUMBERING AND USAGE

Page numbers for front matter will be in lower-case Roman numerals, centered on line 61. The first page following DD Form 1473 (summary or preface) will be page iii. If necessary, the summary or preface can be continued on a reverse page. Otherwise the reverse page will be left blank so that the Preface and/or Table of Contents will begin on a right-hand page. Even-numbered pages are left pages and odd-numbered pages are right pages. This continues throughout the report. The text and appendix pages are numbered consecutively in Arabic numerals. Under no circumstances will pages be numbered according to section, chapter or appendix.

F. SUMMARY

1. A summary is optional but may be included to provide a digest of the report, explain the reason for initiating the work, and outline principal conclusions and recommendations. The summary will present more information on the content of a report than can be contained in the abstract in DD Form 1473. Under no circumstances will it be a duplicate of this abstract.

2. If used, the summary will follow the DD Form 1473 and will be numbered with a lower-case Roman numeral (beginning with iii).

Other front matter page numbers will be adjusted accordingly. For an example, see Appendix A.

G. PREFACE

The preface will include necessary administrative information such as project, task, and work unit numbers and titles; inclusive dates of research reported; date report was submitted by the author; credit for the use of copyrighted material; or acknowledgment of significant assistance received. Acknowledgement should not include thanking project officers or employees for their assistance or for doing their jobs, but should be limited to special assistance essential to the effort. Also include the report numbers and titles of associated efforts and show how they relate to the work reported. The preface will give the period of performance, the name and complete address of the contractor (if a subcontractor, the prime contractor will also be identified), the contract number, the Air Force Engineering and Services Center as the sponsor and the name of the Air Force Engineering and Services Laboratory (AFESC/RD) Project Officer and his office symbol. Prefaces for reports with limited distribution must contain the appropriate limitation statement, as well as the Export Control paragraph required by current DOD directives. Special notices such as reproduction limitations, legal information, safety precautions, disclaimers, compliance with special regulations, or disposition instructions will be included in the prefaces.

If distribution is unlimited the preface must state that the report has been reviewed by Public Affairs (PA) and can be released to the general public including foreign nationals. A review and approval statement with appropriate signature will be included for all reports. For examples of all types of Prefaces, see Appendix A.

H. TABLE OF CONTENTS

Begin the Table of Contents on a new right-hand page. List principal headings (to third-order head only) as they appear in the report, and place the page numbers at the right-hand margin. Put section numbers, if used, at the left-hand margin and indent the headings. For an example, see Appendix A.

Center continuation page headings as follows: TABLE OF CONTENTS (CONTINUED) and/or TABLE OF CONTENTS (CONCLUDED).

Do not use a Table of Contents page for reports of eight pages or less.

Under no circumstances will front matter be listed in the Table of Contents.

I. LIST OF FIGURES

Use listing only if report includes more than four figures. Center continuation page headings as follows: LIST OF FIGURES (CONTINUED) and/or LIST OF FIGURES (CONCLUDED). Titles of Figures will be typed with most important words capitalized (see Appendix A).

J. LIST OF TABLES

Include listing only if report contains more than four tables. Center continuation page headings as follows: LIST OF TABLES (CONTINUED) and/or LIST OF TABLES (CONCLUDED). Type titles with most important words capitalized.

NOTE: Place the Figures and Tables listings on one page if the listings are short. If combined listings are larger than one page, use a separate page for each listing.

K. GLOSSARY OF TERMS

Define all unusual terms the first time they are used in text. If defined in a footnote, use asterisks. If many such terms are needed, repeat them in a Glossary of Terms.

L. ABBREVIATIONS, ACRONYMS, AND SYMBOLS

Abbreviations lend brevity and economy to report writing; however, they should be used sparingly. Spell out each abbreviation the first time it is presented in the text and show the abbreviation in parentheses; e.g., Electromagnetic Pulse (EMP). Spell out short words such as day, mile, ton, foot, yard, inch, meter, gram, hour, liter, second, or pounds. Include units where applicable.

Use standard abbreviations (Government Printing Office (GPO) Style Manual) wherever possible. If necessary, list acronyms or nonstandard abbreviations at the front of the report. List the abbreviations alphabetically in the following order: (1) English capital letters, (2) English lower-case letters, (3) Greek capital letters, (4) Greek lower-case letters, (5) subscripts, (6) superscripts, and special notes. See example in Appendix A.

SECTION V

THE BODY OF THE REPORT (5.4)

A. BREAKDOWN OF TEXT

Divide the body of the report into sections numbered with Roman numerals. Include a First-Order section heading and use Second-, Third-, Fourth-Order and subordinate headings, as required, for clarity. See the examples in Appendix A.

1. Introduction

The Introduction must, as a minimum, be organized into A. OBJECTIVE, B. BACKGROUND, and C. SCOPE/APPROACH. First, state the purpose of the work and provide other general or background information the reader needs to understand the report. Describe briefly the information contained in the follow-on sections. The Introduction should show the relationship between the task being described and previous or current work. It is also desirable to indicate the benefit to be realized if the goal is achieved. Present the Introduction in narrative style. Do not present the scope of the report by repeating the contents. Do not go into such detail that much of the material will be repeated word for word later in the report. Try to provide the reader with a short overview of where you intend to go and how you intend to get there.

2. Main Text

This is an absolute requirement for any technical report and must include information about materials, test equipment, tests performed, techniques, methods, circumstances, calculations, problems encountered, and results obtained. Another individual qualified in the same field should be able to take your technical report and reproduce the work with the same result. The main text may be divided into several separate sections, each with its own title.

Be clear, concise and informative so that those who need the information can obtain it without being saturated by excess verbiage. Remember, professional technical writing is marked by simplicity, accuracy, and readability.

3. Conclusions

To obtain results without reaching conclusions is impossible. These conclusions, whether positive, negative, neutral, good, bad, or indifferent, must be included.

4. Recommendations

This section is optional. However, if recommendations are a logical outgrowth of the work, they should be placed under this heading to provide maximum visibility. Your recommendations may be both immediate and long-term.

B. ARRANGEMENT

1. Text

The text will be divided into logically separate parts, called sections. Each section will be designated by a sequential Roman numeral and a short caption, both of which will be in capital letters. The section designation will be centered on the first typing line of the page with the short caption centered on the page two lines below the section designation line. The text will begin three lines below the caption. Section I begins at the top of the first available full right-hand page following the front matter. All other sections may begin on either a left- or right-hand page. Sections, paragraphs, and subparagraphs will be prepared in the following format. This is the only system acceptable to our Laboratory.

SECTION I

FIRST-ORDER HEADING (U)

A. (U) SECOND-ORDER HEADING

1. (U) Third-Order Heading

a. (U) Fourth-Order Heading

(1) (U) Fifth-Order Heading, usually with run-in text.

Of course, if classification is not required, the portion markings (U) (C) (S) will not be shown.

Although MIL-STD-847B uses the decimal paragraph numbering system, it does not establish this system for use in technical writing. ESL style emphasizes simplicity; therefore, the decimal system is to be avoided.

Classification, if required, will be shown as illustrated above. Space will be used to the maximum extent within printing area limitations. Portions of pages will not be left blank for the purpose of beginning a major paragraph or subsection on a new page.

2. Footnotes (5.5.1)

Identify text footnotes on each page with an asterisk (*), double asterisk (**), dagger (†) or superscript number (¹) depending on the number of footnotes. Place the information at the left margin at the bottom of the page and separate it from text with a solid 1-inch line set flush. This line will be two lines below the last line of text and two lines above the first footnote. Double-space between footnotes but single-space footnotes.

3. References (5.5.1)

A reference gives credit to the work of other authors in the same field of endeavor, is a source of related information, or contains useful facts or information.

A reference is a published document that is available to the reader. Telephone communications, letters, memoranda, personal conversations, and unpublished data are not readily available to the reader and should not be numbered references. Make them footnotes to the text and identify them with an asterisk or, preferably, place them in an appendix. Also, provide enough of an explanation so that the reader is not in doubt about the nature of the communication.

When identifying references in text, precede by the word "Reference" if part of a sentence; otherwise, put in parentheses (Reference 1) although a single number in parentheses may be used to indicate a reference. Do not refer to references in text by author and date. This can also cause confusion or lead to an unnecessarily elaborate numbering system.

4. Reference List (5.5.1)

List references at the back of the report in the same numerical sequence as they appear in the text. Underscore book and report titles and journal names; use quotation marks for titles of journal articles. Include authors, titles, sources, identifying numbers, publishing agency name and address, publication dates, and applicable security classifications. Reference citations must be accurate and complete. Entries must be uniform in style throughout the report. See Appendix B for format and Appendix A for specific examples. Do not list classified references in technical reports with unlimited distribution.

5. Trademarks and Company Names

Trademarks will be kept to a minimum. However, when inclusion in a report cannot be avoided, trademarks will be identified

by an uppercase ® following the name. For example: Teflon®. For reports containing a large number of trademarks, or trademark references, a notice statement on the inside front cover can be used to indicate which products are trade names (see Appendix A).

Company names, trademarks, corporate seals, or mottos shall not be placed on illustrations. The performing contractor's name appears on the cover, on DD Form 1473, and in the Preface.

6. Bibliography (5.5.1)

A bibliography is optional and should be used to list supplementary reports and documents not called out in the text. Bibliographic entries contain the same information as references, but are listed in alphabetical order (by author, whenever possible), and are not numbered.

C. ILLUSTRATIONS (5.6)

Locate illustrations (including figures and tables) as near as possible to the first text reference unless the report contains only a few text pages and many illustrations. In such cases, illustrations may be placed in numerical sequence at the back of the text. Illustrations should be placed so that they may be viewed without turning the page sideways. If this is not possible, place them sideways so that they can be seen by rotating the page clockwise.

Oversize illustrations (foldouts) are to be avoided whenever possible. This can be done by dividing the material to appear on facing or successive pages. If foldouts must be used, make them begin on a right-hand (odd-numbered) page and number as one page with the reverse indicated as blank so that the next page will be odd-numbered. Foldouts must fold out from the binding edge and cannot exceed 10 by 15 inches overall image area (see Figure 1).

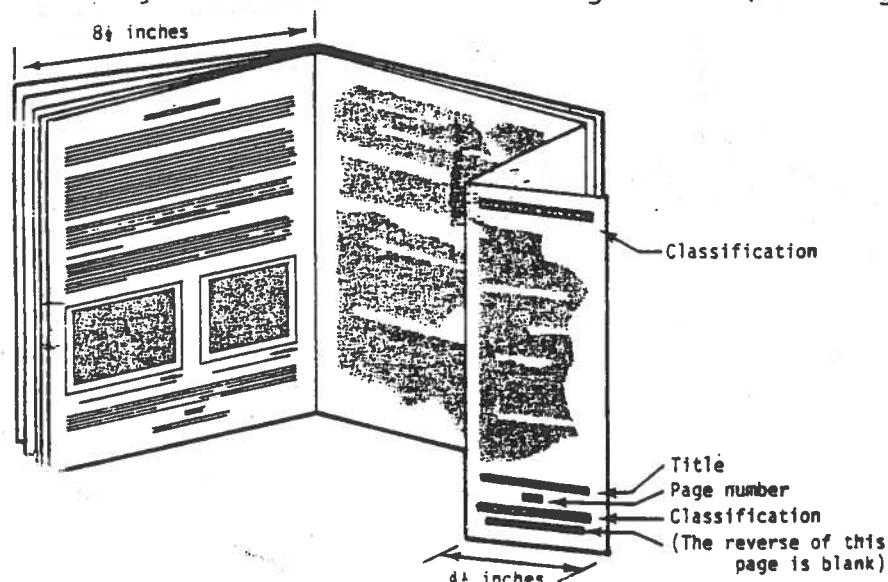


Figure 1. Foldout.

Treat illustrations consistently throughout a report and make sure they supplement the text and are acceptable to the reader. Details, callouts, and numbers should be legible after final reproduction. When practical, crop or mask photographs to eliminate insignificant details. Do not add borders, frames, unnecessary lines or background tones unless they contribute significantly to clarity. Pencil and hand-drawn lines will only be accepted with rough drafts. For reproducible copy, submit clear tone or line art only.

1. Photographs

Photographs will be black and white, prescreened to the required size by Photomechanical Transfer (PMT). Neither color, black and white prints made from color, nor glossy prints will be accepted. Each photograph will be accurately scaled with crop marks. Figure number, page number, report number, and final dimensions in inches will be indicated in the margin below the photograph. A rectangle, dimensionally proportional (final printed size) to the photograph, the figure number and caption of the photograph, and the sequential page number of the report will be properly positioned on a layout page. The dimensionally proportional rectangle will be neatly drawn in black ink or with a red ballpoint pen or covered with a black patch. Distracting details should be avoided. People should not be included except for size comparison or to emphasize a part of the subject. Do not type or write on photos, and do not roll them for shipping. Photographs in text should be labeled as figures, not photos.

When reducing cropped photographs, line graphs and drawings to the space allotted in the page layout, use the dimensions of the picture outlined by the crop lines, because the cropped picture may not be dimensionally proportional to the original.

2. Drawings

Drawings, charts, and graphs will be prepared in black permanent ink on white bond, vellum or tracing paper. Line drawings and charts will contain only information pertinent to the report. Coarse grid lines will be used in graphs, spaced as far apart as practical. Graphs will be free of all lines and lettering not essential to the reader's clear understanding of their message.

Engineering drawings will be simplified and reduced, but not to the point where a legible reproduction cannot be made. Remember that DTIC reduces the Technical Report to microfiche and "prints up" for hard copy, causing small numbers and letters to fade out. All information not pertinent to the report will be deleted. If simplified drawings are still too large and cannot be

satisfactorily reduced to foldout size (printed area not to exceed 10 by 15 inches), a series of drawings will be used (each containing a portion of the total drawing), numbered, and captioned as a continuation of the same figure.

3. Computer Printouts

Computer printouts will be kept to a minimum. When their use is unavoidable, the quality of these printouts will be the same as required for reproducibles. They will be run on unlined paper and either will conform to printing area (6 1/2 by 9 inches) requirements or will be suitable for reduction (not to exceed 20 percent) to meet those requirements. DTIC will not accept poor reproductions of computer printouts. Pages containing computer printouts will be numbered consecutively with arabic numerals, according to where they appear in the text. Page numbers will be centered at bottom of page on line 61. Original copies should be submitted, whenever possible, and figure and table numbers should be assigned sequentially, as appropriate.

4. Reduction

Size-for-size art may be line drawings or photographs to be reproduced the same size as the original. Oversize art is any illustrative copy such as graphs, tables, schematics, etc., that is larger than final page or space size provided. All reductions will be proportional, dimension for dimension, to the nearest 1/8 of an inch.

D. FIGURES (5.6)

1. Numbering

Number figures with Arabic numerals, consecutively, as they appear in the text. Under no circumstances will Roman numerals, decimal numbers, section or chapter designations be used in figure captions within the text. Figure numbers will not be repeated; Example: Figure 1a. Instead, continuation designations will be used; Example: Figure 1. Title (Continued).

Include corresponding letter designations with number for appendix figures; (Example: Figure A-1).

Illustrations in sequence, such as data plots, should be gathered in an appendix.

2. Turned Pages

Place illustrations sideways if too wide for the page. Arrange so that report is turned clockwise to read. Put caption under the figure, not at bottom of page.

3. Captions

Place captions two lines under figures. Use initial capitals for the F in Figure and the most important words in the title. Use same print for figure captions as for text. Make figure captions descriptive but as brief as possible. End each with a period (see Appendix A).

Center one-line captions. Line up subsequent lines of longer captions with the first word of the caption. Allow plenty of space to set off figures placed on a page with text. Keep figure captions to two lines, if possible.

Typical figure caption:

- Figure 1. Geometry of One-Dimensional Calculation of Pulsed Electromagnetic Fields.

For related plots on separate pages:

- Figure 22. Input pulses/output pulses.
- Figure 23. Time history of induced current.
- Figure 23. Title (Continued).
- Figure 23. Title (Concluded).

4. Identification in Text

When identifying illustrations in text, precede by the word "Figure" if part of a sentence; otherwise, put in parentheses (Example: Figure 15).

5. Figures in Series

Plots in a series such as time, distance, volume, etc., with one caption may show "Figure 1. Title (Continued)." on each continued plot and "Figure 1. Title (Concluded)." on the final plot.

6. Camera-Ready Copy (CRC)

Submit original art work; first-run computer printouts of plots, data, etc., with sharp clear print; and glossy photographs, whenever possible.

7. Source of Figures

Illustrations taken from other reports will show the source information in parentheses at the end of the figure caption.

8. Explanatory Information

Label (call out) all information on figures; the reader should not have to refer back to the text for such information as units, meanings of solid, dashed, dotted lines, shading, etc. Text explanation should refer to related data, comparisons of measurements and results, etc. Use abbreviations and symbols, if adequately defined, in the text. Be consistent in use of upper or lower case letters; match callouts and letters with those in text.

E. TABLES (5.7)

Tables should be as simple as possible so that the reader can easily grasp the meaning of the data. Avoid vertical and horizontal lines whenever spacing can be used effectively.

Align tabular material, especially numbers, in neat and orderly fashion. Avoid crowding and cluttering. Be sure that title and boxheads are precise and accurate. Separate the column headings from the body of the table with a horizontal line.

Give applicable units of measure or degree in the column headings of tables. When tables continue on two or more pages, note the continuation and repeat the column headings and rules on each page, except column headings need not be repeated on the second page for continuations on two facing pages turned sidewise.

1. Numbering

Number tables in Arabic numerals, consecutively, as they appear in text. No chapter, decimal, or section designations will be used as part of table numbers in text.

Include corresponding letter designation with number for tables in appendices (Example: TABLE A-1).

2. Turned Pages

Place tables sideways if too wide for page. Arrange so that report is turned clockwise to read.

3. Titles and Column Headings

Center the table number and title above the table in capital letters using the same size print as for text. Capitalize only the first word of a column heading. Place entire title on one line, if possible. Use all caps for "TABLE 1. TITLE (CONTINUED)." on each continued page and "TABLE 1. TITLE (CONCLUDED)." on the final page.

4. Identification in Text

When identifying tables in text, precede by the word "Table" if part of a sentence; otherwise, put in parentheses (Example: Table 1).

5. Footnotes to Tables

Use superscripts a, b, c, etc., to identify footnotes to tables. Place the superscript letter after words but before numbers, with no space in between. Place table footnotes under the tables, not at the bottom of the page of text. Indent first line five spaces from the left margin of the table; put subsequent lines at the margin of the table.

6. References on Tables

When Tables are taken from another source, list the source in parentheses after the table title.

7. Abbreviations and Explanations

Tables should stand alone; the reader should not have to refer back to the text to understand the table. Abbreviate in column headings, if necessary, because of space limitations. Place explanation below the table at "Notes." Include units of measure or degree in the column headings; do not repeat in the columns.

8. Camera-Ready Copy (CRC)

Submit original print, if possible. Tables on computer printout sheets must have sharp, clear, unbroken print. See sample table in Appendix A.

F. APPENDIXES (5.5.2)

Appendixes may be used for material related to or additional to the report, not essential to understanding the text, but which provides vital details to the critical reader. They may provide detailed descriptions or explanations of some points in the text such as test data, justification of an assumption, derivations of formulas, tabulations of frequent reference, details of special instrumentation and lists of materials. An appendix will not include information which logically belongs in the text, e.g., specifications, exhibits, and project work requirements. The appendix number and caption will be positioned on the page in the same manner as section headings. Appendix A must begin on a right-hand page. If separate title pages are used for appendices, each title page will begin on a right-hand page. Page numbering is a

continuation of text page numbering. Separate Table of Contents, List of Figures, or List of Tables are not needed. These should be included in appropriate front matter.

Figures, tables, equations, and references in appendices will be numbered with the letter designation of the appendix in which they appear, followed by a dash and the sequential number of the figure, table, equation, or reference in the appendix. For example, Figure A-1, Table B-2, Equation (A-7), Reference B-4.

One reference list should suffice for the text and appendices. If one list is used, continue consecutive arabic numbering for references. This list should appear after the last appendix. If separate lists are used for each appendix, number references A-1, A-2, etc. and place list at end of each appendix.

SECTION VI

SECURITY CLASSIFICATION, PROPRIETARY DATA AND OTHER STATEMENTS

A. SECURITY CLASSIFICATION

1. The front and back covers of each classified report will be marked, top and bottom, with the overall classification of the document (see example in Appendix A). Each page will be marked conspicuously, according to its own content, centered at top and bottom, in letters larger than the letters in the text. Security classification markings may be affixed to reproducibles by pre-printing on pages, by applying preprinted marking to pages, by transfer paper, or by other similar methods. Markings WILL NOT be rubber-stamped on photographs or slick or glossy reproducibles.

2. Every element--heading, subheading, caption, paragraph, figure, and table--in a classified report will be marked individually with the appropriate classification of the information contained in that particular element. The classification of a paragraph will be shown in parentheses at the beginning of the paragraph. The following abbreviations will be used: (U) for UNCLASSIFIED, (C) for CONFIDENTIAL, (S) for SECRET. When appropriate, the symbols "RD" for Restricted Data and "FRD" for Formerly Restricted Data will be added, e.g., (C-FRD). The classification of each subparagraph will be marked. The classification of a figure or table will be shown within or contiguous to the figure or table at the lower right-hand edge, as viewed, so that the marking will be conspicuous and will be reproduced on any copies made. Abbreviated classification markings will not be used on figures and tables. The classification of the caption is abbreviated in parentheses between figure or table number and caption. In the List of Figures and List of Tables, the abbreviated classification in parentheses is required between the figure or table numbers and the respective caption. NOTE: Classification of Titles or Headings is to be avoided wherever possible. In the Table of Contents, each component will carry the same classification as is given for it in the text.

3. Classified references WILL NOT be listed in reports having Distribution Statement A.

B. SPECIAL CONTROL MARKINGS

1. Not Releasable to Foreign Nationals (NOFORN)

When NOFORN data are included in a report, this statement--Not Releasable to Foreign Nationals--MUST BE included on the covers, in Block 3 of the DD Form 1473, and on the bottom of each page on which such material appears. In addition, each paragraph, figure, or table containing such information must be so

marked. The abbreviation, NOFORN, may be used following the classification of the paragraph. For example: (S-NOFORN). The abbreviation, NOFORN, may be used following the spelled out classification of that table or figure. For example: SECRET-NOFORN.

2. WARNING NOTICE--Intelligence Sources and Methods Involved (WNINTEL)

This statement will appear on the covers, on the DD Form 1473, and on each page on which such information appears. Each paragraph, figure, and table containing such information will carry, in addition to any other classification, the abbreviation WNINTEL. Example: (S-NOFORN-WNINTEL). If both NOFORN and WNINTEL appear on the same page, the two statements can be typed on either side of the page number, two spaces below the last line of text.

3. See AFR 205-1 for warning notices for RD FRD, other special markings, and for specific details.

C. PROPRIETARY DATA

These data shall be marked in accordance with Defense Acquisition Regulation 7-104.9(a). Limited rights shall be effective, provided the PROPRIETARY identification is shown ONLY for that portion (paragraph, figure, or table) or portions of any technical report to which PROPRIETARY applies. The distribution of such TRs shall be limited. In addition, the report will be marked as follows.

a. Cover. THIS REPORT CONTAINS PROPRIETARY INFORMATION.

b. Inside front cover is marked with the legend below in which is inserted:

(1) The number of the prime contract under which the technical data is to be delivered.

(2) The name of the Contractor and any subcontractor by whom the technical data was generated, and

(3) An explanation of the method used to identify limited rights data.

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Contract No.

Contractor:

Explanation of Limited Rights Data Indication Used: THE WORD "PROPRIETARY" IS USED TO IDENTIFY EVERY PIECE OF LIMITED RIGHTS DATA.

Those portions of this technical data indicated as limited rights data shall not, without the written permission of the above Contractor, be either (a) used, released, or disclosed in whole or in part outside the Government, (b) used in whole or in part by the Government for manufacture or, in the case of computer software documentation, for preparing the same or similar computer software, or (c) used by a party other than the Government, except for: (i) emergency repair or overhaul work only, by or for the Government, where the item or process concerned is not otherwise reasonably available to enable timely performance of the work, provided that the release or disclosure hereof outside the Government shall be made subject to a prohibition against further use, release or disclosure; or (ii) release to a foreign government, as the interest of the United States may require, only for information or evaluation within such government, or for emergency repair or overhaul work by or for such government under the conditions of (i) above. This legend, together with the indications of the portions of this data which are subject to such limitations shall be included on any reproduction hereof which includes any part of the portions subject to such limitations.

c. DD Form 1473. Blocks 3 and 19, add: "THIS REPORT CONTAINS PROPRIETARY INFORMATION." Type in all caps before other data appearing in these blocks.

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f. Figures and Tables. Add: (PROPRIETARY) after required classification. Example: "UNCLASSIFIED (PROPRIETARY)."

g. General. At bottom of each page containing proprietary data add: "This page contains proprietary information." This notation can be typed to one side of the page number on either side of the page two lines below last line of text.

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The following statements or similarly worded statements may also be used on an "as-needed" basis:

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"This report has been authored by a contractor/employee of the United States Government. The United States Government retains a nonexclusive, royalty-free license to publish or reproduce the material contained herein, or allow others to do so, for the United States Government purposes."

"This report discusses laboratory and field testing of _____[®] for the repair of scab (spall) damage to runways. It does not constitute an endorsement of this product, nor can it be used for advertising the product."

"This report discusses field tests of two previously identified small crater repair methods and discusses the use of materials for bomb damage repair. The report does not constitute an endorsement or rejection of these products, nor can it be used for advertising a product."

Other statements and disclaimers can be formulated as needed.

E. COPYRIGHTED MATERIALS

When contractor-produced reports contain illustrative or other material reproduced from copyrighted sources, the contractor preparing the reports must submit written evidence that he has obtained permission to reproduce the material for the technical report. Final TRs submitted without this evidence will not be accepted as reproducible copy and payment may be withheld. The technical editor will provide guidance on marking illustrations and assist in preparing copyright notices.

SECTION VI

OTHER TECHNICAL LITERATURE

A. TEST PLANS

Because no previous written guidance for formatting ESL test plans exists, a uniform procedure is needed. In response to requests from project officers and contractors preparing these documents, the following guidelines are offered:

1. Format

Test Plans should follow the basic standard outline format (traditional) presently required for ESL TRs.

2. Organization

A logical organizational pattern for a test plan would be as shown below:

SECTION I: INTRODUCTION

SECTION II: PURPOSE OF PROGRAM

SECTION III: RESPONSIBILITIES

SECTION IV: TEST OBJECTIVES

SECTION V: TEST DESCRIPTIONS

SECTION VI: SAFETY

SECTION VII: ENVIRONMENTAL IMPACT

Annexes can be added, as required, to tell the individual people and teams how to carry out their portion of the plan.

3. Annexes vs. Appendixes

Appendixes are used with ESL TRs, either to present supplementary information or to give details neither available to nor needed by all readers. Annexes, however, are preferred with test plans because they outline specific tasks or information required by specific teams or persons in carrying out their part of the plan. In addition, the test plan will often become an appendix to a technical report. In such cases, the use of annexes in the test plan eliminates the awkward situation of adding an appendix to an appendix. When adding material to an annex, make the added material an addendum or tab rather than an appendix.

4. Language and Style

Test plans should be clear, concise, readable, and should consist only of the information needed to perform the testing. Therefore, superfluous words and informational overkill should be avoided.

5. Editing

Test plans, in both draft and final form, should be edited by RDXI.

B. STATEMENTS OF WORK (SOWs)

All too often, improperly written statements of work produce an unsatisfactory technical report or do not establish time intervals for production of the report. This is particularly true of non-Purchase Request (PR) reports where our appendix is not written into the contract as it is processed through RDXP and Eglin AFB.

Project Officers should be especially careful to assure that Section 5.0 of each statement of work for non-PR contracts contains at least the following statement:

"Provide a final camera-ready technical report, meeting standards outlined in MIL-STD-847B, as amended by the attached appendix, and by the ESL Handbook for the Preparation of Technical Reports. The draft shall be submitted within 30 days after completion of the technical effort. Upon contractor receipt of the edited and technically reviewed draft, the contractor shall incorporate all editing and technical changes into the report and submit final camera-ready copy 30 days after receipt of edited draft."

Remember, that if we are funding over 50 percent of the effort, we will edit and publish the report according to our standards, therefore, your statement of work must be written to assure adherence to these requirements.

The general format for a statement of work is shown in Figure 2 and Section 5.0 should place special emphasis on timeliness and quality of the final TR. To assist in quality control, the technical editor should be asked to review all draft statements of work.

C. JOURNAL ARTICLES, SYMPOSIA PRESENTATIONS

The technical editor will assist you in preparation of articles submitted for publication in technical or scientific journals or to be published as part of symposium proceedings. The following

STATEMENT OF WORK

XXX

XXXXX XXXXX XXXXX XXXXX

1.0 INTRODUCTION

1.1 XXXXX XXXXX XXXX XXXXX XXXXX XXXXX XXX XXXXX XXXX XXXX XX
XXXXXXXX XX XXXXXX XXXX XXXXXX XXX XXXXX.

1.2 XXXXXXXXXXXX XXXX XXXXX XXXX XXXXX.

1.3 XXXXX XXXXX XXXXX XX XXX XXXXX XXXX XXXX.

1.3.1 XXXXX XXX XXXXX XXX XXXXX XXX XXXXXX.

1.3.2 XXXXX XXX XXXXX XXX XXXXX XXX XXXXXX.

2.0 SCOPE

2.1 XXXX XXXX XXXXXX XXXXX XXXXX XXXXXX XXXXXX XXXX.

2.2 XXXXXXXXXXXXXXXXXXXX XXXXXXXXXXX XXXXXXXXXXX XXXX XXXX XXX.

3.0 BACKGROUND

3.1 XXXXXX XXXXX XXXX XXX XX XXXXXXXX

3.2 XXXX XXXXXXXX XXXXX XXXXXXXX XXXXXXXX XXXXXXXX XXXX XXX

3.2.1 XXXX XXXXXXXX XXXXXXXX XXXXX XXXXXXX XXXXXXXX

3.2.2 XXXX XXXXXXXX XXXXXXXX XXXXX XXXXXXX XXXXXXXX

3.2.2.1 XXXXXXXXXXXXXXXXXXXX XXXXXXXX XXXXXXX XXXXX

4.0 TECHNICAL REQUIREMENT

4.1 XXXXX XXXXXXX XXXXXXX XXXXXXX XXXXXXX XXXXXXX XXXXXXX

4.2 XXXXX XXXXXXX XXX XXXX XXXXX XXXXXXX XXXXX XXX XXX XX

5.0 REPORTS, DATA AND OTHER DELIVERABLES

5.1 XXXX XXXX XXX XXXXXXXXXXX XXXXXXX XXX XXXXX XXXXXXXX

5.1.1 XXXXX XXXXX XXXXX XXXX XXXX XXXXXXXXXXXXXXX XXX

5.1.2 XXX XXXX XXXXX XXXXX XXXXX XXXX XXXXXXX XXX

Figure 2. Example for Statement of Work.

general principles should be remembered when considering such articles.

1. Submit the draft for editing sufficiently in advance of publication. It would also be helpful to submit a copy of the journal to which the article is being submitted so that editing can be done according to the standards of the publication involved.

2. All articles submitted for publication, as well as all papers prepared for presentation, must be approved for public release. This means that Public Affairs must have time to review the article.

3. A handy reference work for preparation of articles is Robert A. Day's How to Write and Publish a Scientific Paper. Some general rules are excerpted from this excellent book. They are :

a. "Don't start vast projects with half-vast ideas." Be sure that your entire article is well thought out and that at least a tentative outline is written before you begin.

b. Remember that a scientific or technical paper must contain sufficient information to enable peers to (1) assess observations, (2) repeat experiments and evaluate intellectual processes. It must also be susceptible to sensory perception, permanent, available to the scientific community, and obtainable from an information retrieval service.

c. The paper must show a definite pattern of organization to assure good organization. Four questions must be answered.

(1) What was the problem? Answered by the Introduction.

(2) How did you study the problem? Answered by Materials and Methods.

(3) What did you find? Answered by Results.

(4) What do these findings mean? Answered by Discussion.

Remember, that with proper organization, your paper will write itself.

4. The language used should be appropriate to the audience. Simple, concise language interspersed with technical information will make a complex topic easier to read or put another way, "The Ph.D. in science can make journal editors quite happy with plain, unadorned eighth-grade composition."

5. Use a short title which previews the topic in one or two lines but carries no excess baggage. Do not let syntax of title

confuse meaning (example: Preliminary and Canine Evaluation of a New Antitumor Agent). Do not clutter title with abbreviations, chemical formulas, proprietary names, and jargon that would make indexing difficult.

6. Obey all grammatical rules but write for the reader and avoid use of excess words and phrases that clutter the text. Some examples are: it should be noted that, relating to the subject matter of, on the order of, in the vicinity, of in close proximity to, in my opinion it is not a justifiable assumption that, etc. George Eliot said "Blessed is the man who, having nothing to say, abstains from giving us wordy evidence of this fact."

7. Use only standard, recognizable abbreviations and keep them to a minimum. Spell out all nonstandard abbreviations and acronyms the first time used. Only abbreviate units of measurement when used with a numeral.

8. Be sure that all charts, graphs, tables, and photographs are necessary, in good taste, reproducible, and in keeping with publication instructions of the journal in question.

9. Typing of final manuscript should be according to instructions provided by the journal editor.

If you must fulfill the "publish or perish" requirement, bring your masterpiece to your technical editor and give him time to help.

D. AIR FORCE MANUALS, PAMPHLETS AND REGULATIONS

Air Force publications are written according to different standards, especially readability guidelines found in AFR 5-1 and criteria found in AFR 5-8. Be sure that you read this publication or have your contractor read it before your publication reaches the draft stage. Also, be sure to inform the Technical Editor that the proposed publication is intended as an Air Force manual, pamphlet, or regulation before submitting it for initial editing.

APPENDIX A

EXAMPLES OF TECHNICAL REPORT FORMAT

This Appendix presents examples to be used in preparation of ESL technical reports. In some cases, they represent excerpts from previously published reports. In other instances, it became necessary to amend or fabricate to provide the user with the best possible guidance. Put another way, what you see here is not to be regarded as an excerpt from a previously published report, and is to be used only as a guide to preparing camera-ready copy.

A Limited Test of Solvent Reclamation at an Air Force Flightline Facility

GLENN E. TAPIO

**ENVIRONICS DIVISION
ENVIRONMENTAL ENGINEERING BRANCH**

FEBRUARY 1985

**FINAL REPORT
APRIL 1980 - OCTOBER 1984**

APPROVED FOR PUBLIC RELEASE: DISTRIBUTION UNLIMITED



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Figure A-1. Front Cover - Unlimited Distribution.

Engineering Development and Testing of Advanced Materials and Methods for Bomb Damage Repair Part I of III

C. KISTLER, A.S. KUBO, D.L. READ

THE BDM CORPORATION
7915 JONES BRANCH DR
McLEAN, VA 22102

BATTELLE COLUMBUS LABORATORIES
505 KING AVE
COLUMBUS, OH 43201

JANUARY 1985

FINAL REPORT
MAY 1982 - OCTOBER 1983

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Figure A-2. Front Cover - Limited Distribution.

Aircraft Skin Penetrator and Agent Applicator, Volume II, Test and Evaluation (Volume II of II)

R.H. CUTHBERTSON

AMETEK, INC./OFFSHORE RESEARCH & ENGINEERING DIV.
1224 COAST VILLAGE CIRCLE
SANTA BARBARA, CA 93108

NOVEMBER 1984

FINAL REPORT
MARCH 1983 - DECEMBER 1983

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NAVAIR

NAVAL AIR SYSTEMS COMMAND
DEPARTMENT OF NAVY,
WASHINGTON DC 20361

SECRET

ESL-TR-83-53

Siting of Redundant Airfield Surfaces Volume II: Analysis for Hahn and Osan (Volume II of II) (U)

K.C. STOEHRMANN, R.D. RIGGIN, F.J. HAMLIN,
J.M. WHITEHEAD, and M.A. THOMPSON-DOUGHERTY

THE BDM CORPORATION
7915 JONES BRANCH DRIVE
McLEAN, VA 22102

MAY 1984

FINAL REPORT
APRIL 1983 - SEPTEMBER 1983

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Figure A-4. Front Cover - Classified.

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Figure A-5. Inside Front Cover - Unlimited Distribution Notice.

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Figure A-6. Inside Front Cover - Limited Distribution Notice.

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Amalgapave	Furathane	Pre-Krete	Sylnax
Araldite	Farez	PepSet	Speed Rock
Bostik	Garonite	Petro Set	Terrafix
Bidium	Hetron	Phoschek	Typar
Capcure	Horn	Pyran	Vazo
Ciba	Heloxy	Por-Rock	Vicure
Chem Rez	Innoset	PemCo	Wirand
Dow	Kevlar	Pyran	Wollastonite
Darex	Kitchen Aid	Reg-Set (Probe G)	XR 2391
Duracal	Lupersol	Reemay	Zor-X
Epon	Lumnite		

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Figure A-7. Inside Front Cover With Trademark Notice.

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2b. DECLASSIFICATION / DOWNGRADING SCHEDULE			5. MONITORING ORGANIZATION REPORT NUMBER(S) ESL-TR-84-58		
4. PERFORMING ORGANIZATION REPORT NUMBER(S) BDM/W-84-0961-TR			7a. NAME OF MONITORING ORGANIZATION Air Force Engineering and Services Center (RDCR)		
6a. NAME OF PERFORMING ORGANIZATION The BDM Corporation		6b. OFFICE SYMBOL (if applicable)	7b. ADDRESS (City, State, and ZIP Code) HQ AFESC/RDCR Tyndall Air Force Base, Florida 32403		
6c. ADDRESS (City, State, and ZIP Code) 7915 Jones Branch Drive McLean, Virginia 22102		9. PROCUREMENT INSTRUMENT IDENTIFICATION NUMBER F08635-80-C-0206			
8a. NAME OF FUNDING / SPONSORING ORGANIZATION		8b. OFFICE SYMBOL (if applicable)	10. SOURCE OF FUNDING NUMBERS		
8c. ADDRESS (City, State, and ZIP Code)		PROGRAM ELEMENT NO. 72894F	PROJECT NO.	TASK NO.	WORK UNIT ACCESSION NO.
11. TITLE (Include Security Classification) Fabrication of Fiberglass Mats					
12. PERSONAL AUTHOR(S) Godfrey, E. A., Dunn, G. F., Bolduc, D. J., Moats, R. K., Richford, M.L.					
13a. TYPE OF REPORT Final		13b. TIME COVERED FROM 83 09 16 TO 84 12 03		14. DATE OF REPORT (Year, Month, Day) February 1985	
15. PAGE COUNT 82					
16. SUPPLEMENTARY NOTATION Subject to export control laws. Availability of this report is specified on reverse of front cover.					
17. COSATI CODES			18. SUBJECT TERMS (Continue on reverse if necessary and identify by block number)		
FIELD	GROUP	SUB-GROUP	Fiberglass Mats Pavement Repair Mat Fabrication		
11	09		Bomb Damage Repair Material Safety		
13	02		Polyurethane Advanced Materials		
19. ABSTRACT (Continue on reverse if necessary and identify by block number) This field manual documents procedures for fabricating polyurethane-impregnated fiberglass mats. The mats are to be used with crushed stone base course as an interim repair method for bomb-damaged runways. The manual outlines material handling and safety procedures. A list of materials, tools, and equipment required to outfit fabrication teams is also included.					
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4. PERFORMING ORGANIZATION REPORT NUMBER(S) ESL-TR-84-51			7a. NAME OF MONITORING ORGANIZATION		
6a. NAME OF PERFORMING ORGANIZATION Air Force Engineering and Services Center		6b. OFFICE SYMBOL (if applicable) RDCS	7b. ADDRESS (City, State, and ZIP Code)		
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8a. NAME OF FUNDING/SPONSORING ORGANIZATION Air Force Office of Scientific Research		8b. OFFICE SYMBOL (if applicable) NA	10. SOURCE OF FUNDING NUMBERS		
8c. ADDRESS (City, State, and ZIP Code) AFOSR Bolling AFB Washington DC 20332		PROGRAM ELEMENT NO. 6.2	PROJECT NO. 2673	TASK NO. 0025	WORK UNIT ACCESSION NO. N/A
11. TITLE (Include Security Classification) Finite Element Analysis of Centrifuged Concrete Culverts					
12. PERSONAL AUTHOR(S) Yong S. Kim					
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19. ABSTRACT (Continue on reverse if necessary and identify by block number) The objective of this study was to develop an improved design tool to better predict the soil-structure interaction of underground protective structures using finite element analysis and centrifuge modeling technology. This study shows that the results obtained from an existing finite element computer code, CANDE, and actual centrifuge behavior is quite favorable. Two soil models, a linear model and Duncan's hyperbolic model, were used to show the influence of constitutive relationships on the overall response of the system.					
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2b. DECLASSIFICATION / DOWNGRADING SCHEDULE					
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09	02		Bomb Damage Repair Times Resource Allocation		
			Project Scheduling Scheduling		
			Rapid Runway Repair		
19. ABSTRACT (Continue on reverse if necessary and identify by block number) This Technical Report is divided into three volumes, Volume I explains the Computer Model for Bomb Damage Repair times, while Volume II contains the Appendix and Volume III is the User's Manual. The computer model for Bomb Damage Repair (BDR) times is used to schedule BDR activities and allocate BDR resources. The model input is a problem description written in the new simulation language, HANDRAIL (Hueristic - continued on back of page)					
20. DISTRIBUTION / AVAILABILITY OF ABSTRACT <input type="checkbox"/> UNCLASSIFIED/UNLIMITED <input checked="" type="checkbox"/> SAME AS RPT. <input type="checkbox"/> DTIC USERS			21. ABSTRACT SECURITY CLASSIFICATION UNCLASSIFIED		
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SUMMARY

During the emission test program, conducted June 2 - 3, 1982, eight events, or loading operations, were observed and tested (Table 1). Five truck loadings and three tank transfers occurred during the test period. A list of the truck loading events is found in Table 2. Mass emission rates of NO_x , CO, and THC were determined and found to be well below AP-42 standards for similar processes (Tables 4 and 5). Combustion efficiencies from these eight events ranged from 99.67 to 99.84 percent (Table 3). Destruction efficiencies ranged from 95.9 to 99.5 percent. Outlet concentrations of NO_x , O_2 , CO, CO_2 , and THC were monitored continuously. Inlet hydrocarbon samples were collected in bags and analyzed onsite on a gas chromatograph equipped with a flame ionization detector (G.C. - FID).

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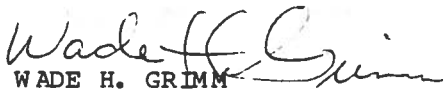
Figure A-11. Example of Executive Summary.

PREFACE


This report was prepared by USAF School of Aerospace Medicine (USAFSAM/VNC), Brooks AFB TX 78235, under Contract Number F08635-84-C-0270, for the Air Force Engineering and Services Center, Engineering and Services Laboratory (AFESC/RDCF), Tyndall Air Force Base, Florida 32403-6001. This work was sponsored by the Naval Air Systems Command (NAVAIR) and the US Air Force Engineering and Services Center (AFESC). Mr Joseph L. Walker, Mr Wade Grimm (AFESC), and Ms Phyllis Campbell (NAVAIR) were the Government technical program managers. This report summarizes work accomplished between 4 January 1983 and 30 June 1984.


This report has been reviewed by the Public Affairs Office and is releasable to the National Technical Information Service (NTIS). At NTIS, it will be available to the general public, including foreign nations.


This technical report has been reviewed and is approved for publication.


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Project Manager, Fire Research
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Chief, Engineering Research
Division


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Deputy Director, Engineering and
Services Laboratory

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Figure A-12. Preface for Unlimited Distribution.

PREFACE

This report was prepared by the BDM Corporation, 7915 Jones Branch Drive, McLean, VA 22102, under contract F08635-84-C-0185, for the Air Force Engineering and Services Center, Engineering and Services Laboratory, Tyndall Air Force Base, Florida.

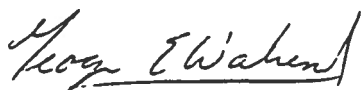
This report summarizes work done between July 1984 and July 1985. Captain G. E. Walrond was the AFESC/RDCP Project Officer.

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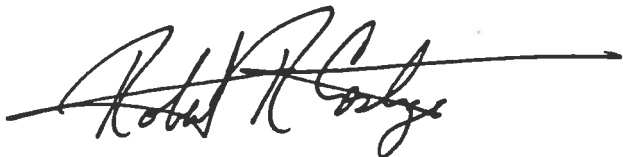
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GEORGE E. WALROND, Capt, USAF
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Figure A-13. Preface for Limited Distribution.

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LIST OF ABBREVIATIONS

A/C	Aircraft
AGE	Aerospace Ground Equipment
Alt	Altitude
ASD	Aerospace Systems Division
ATC	Air Traffic Control
AWADS	Adverse Weather Aerial Delivery System
CAZ	Cursor Azimuth
CR	Cursor Range
DT&E	Development Test and Evaluation
Dz	Drop Zone
J boxes	Junction Boxes
LEDs	Light-Emitting Diodes
MAC	Military Airlift Command
mm	Millimeter
MSL	Mean Sea Level
MSALT	Mean Sea Level Altitude
OAP	Offset Aiming Point
PPI	Planned Position Indicator
ROC	Required Operational Capability
ROMs	Read Only Memories

Figure A-17. List of Abbreviations.

LIST OF SYMBOLS

A	constant
B	disk radius
C_M	mass transfer station number
h	enthalpy, thickness
k	optical constant, reaction rate constant
P	pressure, power
Pr	Prandtl number
w	mass rate
Z	mass fraction
V	absorptivity, absorption coefficient, coefficient of thermal expansion
J	thickness
m	emissivity, strain

Subscript

a,b,c	components of solid
conv	convective
rad	radiation
T	total

Superscript

t^w	evaluated at wall temperature
o	reference state, usually 290°K
*	condensed phase

Figure A-18. List of Symbols.

GLOSSARY OF TERMINOLOGY

Aftmost Box - Each chord on each planform and diaphragm combination has one such box. It is the aftmost box on that chord for which AIC arrays must be calculated and may be on the planform or diaphragm.

AIC - Aerodynamic Influence Coefficient.

Area Ratio - On-planform fraction of a box which is cut by the planform boundary.

Apex Box - The box on the sending surface which encloses the apex of the Mach hyperbola associated with the receiving box.

Box Grid - Nondimensionalized geometric array of boxes whose extent is determined by the geometric properties of the planforms. The term "grid" embraces the arrays on both surfaces.

Control Point - The location at which a receiving box is deemed to be influenced by other boxes. In general, the center of the receiving box.

Effective Area - A concept which relates entirely to the subdivision technique. It is composed of those boxes sufficiently close to the receiving box that their influence on it is large enough for the subdivision refinement to significantly affect results. The size has been arbitrarily set to include the N_{BOX}/N_S rows immediately ahead of the receiving box.

Global Coordinate System - System X aft, Y right, Z up. $Y = 0$ at centerline of airplane.

Leading Edge Diaphragm - All diaphragms on which $0 = 0$.

Local Coordinate System - A coordinate system lying in the plane of the surface. X aft, Y root to right tip. $Y = 0$ at center line of airplane.

Longitudinal Separation - Streamwise distance between the trailing edge of the wing and the leading edge of the tail, measured along the centerline.

C. SURVEY OF DISTRIBUTED DATA BASE MANAGEMENT SYSTEMS

In this section, the five systems surveyed are the most relevant to the project described in the introduction. The systems are MULTIBASE, R*, SDD-1, distributed INGRES and CSIN. This discussion covers the architectures of these systems and the processing of queries by the individual systems in a distributed environment.

1. The MULTIBASE System

a. Background

MULTIBASE is a distributed data base system that provides the users an integrated access to preexisting, heterogeneous distributed data bases (References). It is a software system that allows end users to query the data base in a common query language. Since all the component data bases are heterogeneous, the main goal of MULTIBASE is to provide a fast, easy and integrated access/retrieval system for the various heterogeneous data bases without changing the local data base systems or their application programs.

MULTIBASE is a read-only data base, and updates can be done only where the data object is stored. Therefore, each local site maintains autonomy for updates. Local application programs can operate using the existing local interfaces. The language provided to global users by MULTIBASE is called DAPLEX (Reference), which is a data definition and manipulation language for data base systems. The model used is the functional data model (Reference).

b. Architecture of MULTIBASE

MULTIBASE is particularly interesting to us since it deals with the problem of integrating heterogeneous data bases. The schema architecture and the component architecture are the most important elements to understand in the overall architecture of MULTIBASE.

(1) Schema Architecture

The task of providing the users with a uniform data base involves not only a "homogenization" of the various heterogeneous data bases, but also a resolution of data incompatibilities to produce integration.

There are three levels of schemata, a global schema (GS) at the top, an integration schema (IS) and one local schema (LS) per local data base at the middle level, and one local host schema (LHS) per local data base at the bottom level (see Figure 2). The LHSs are the preexisting local schemas which may be defined by a variety of data models. The LHS is mapped into the LS which is defined by the functional data model. Therefore, the LSs are expressed in only one common data model. The IS, together with the LSs, provides the integration of the various data bases and resolves data (scale, name,

Figure A-20. Sample Page of Text.

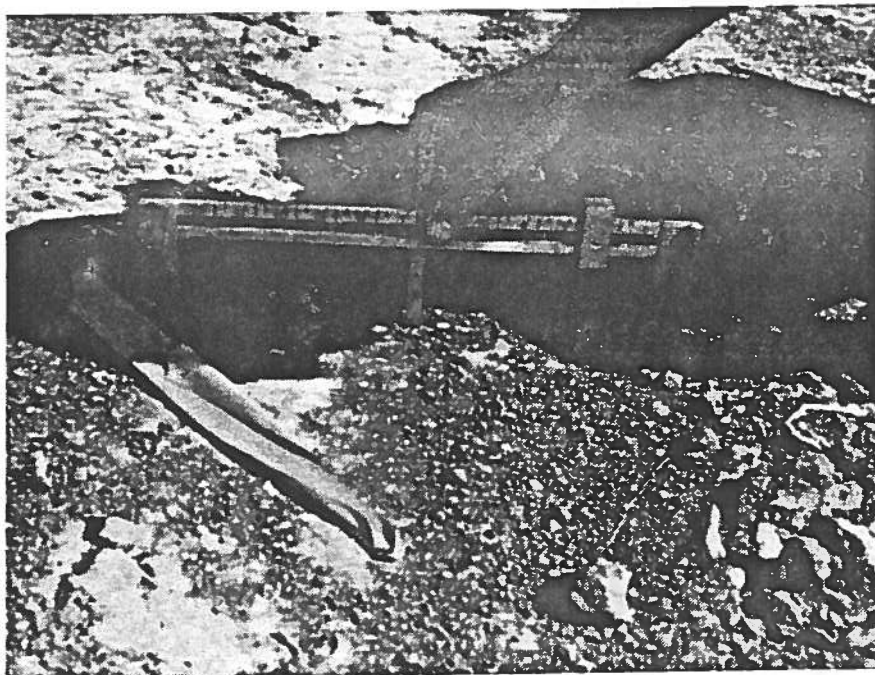


Figure 21. Rut Depth Gage.

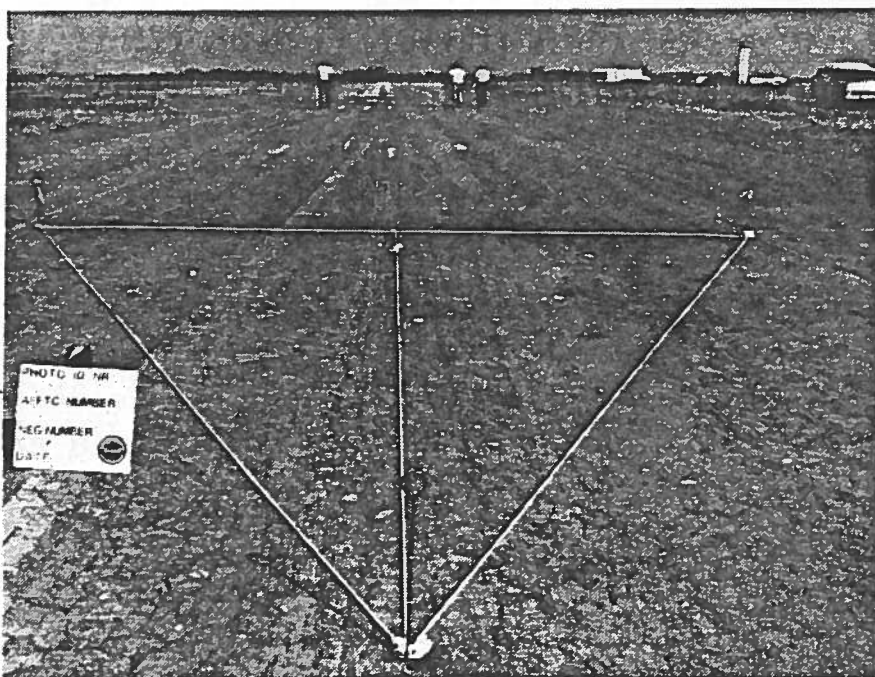


Figure 22. Triangle-Shaped String Line Used for Aircraft Attitude Measurement.

Figure A-21. Sample Figure.

TABLE 3. SCALING RELATIONSHIPS FOR NOMINAL VALUES WITH LINEAR SCALING.

Quantity	Nominal Test Values	Full Scale Values
p (psi)	200	200
D (in)	12.5	18
d (in)	1.0	1.5
V (mph)	40	40
water depth (in)	0.35	0.5
weight (lbs)	1000	2100

tactical aircraft. A flat-tread tire footprint increases to full width as light loads are applied and footprint length grows as loads are increased to full operational levels. Both the width and length of the test tire's footprint increase as load levels are increased within the tire's load-carrying capability.

Viscosity scaling is accomplished by increasing the velocity by s . Thus, for the nominal test condition ($V^L = 40$ mph), viscosity effects are the same as for an aircraft velocity of 28 mph. A particle that is accelerated by fluid drag to a certain velocity in the lab test would be accelerated to $1/s$ times that velocity in a full-scale encounter. The variation of viscous effects with Reynolds number can be determined by running at a higher velocity, to obtain a value of the Reynolds number close to that characteristic of water flow under a full-scale tire.

Figure A-22. Sample Table.

REFERENCES

1. Stanton, R.M., The Thermal Response of PBI and Nomex® II Fabrics Exposed to a JP-4 Fuel Fire, AFML-TR-73-27, Air Force Materials Laboratory, Wright-Patterson Air Force Base, Ohio 45433, May 1973, UNCLASSIFIED.
2. Crose, James G., ASAAS, Asymmetric Stress Analysis of Axisymmetric Solids with Orthotropic Temperature-Dependent Material Properties that Can Vary Circumferentially, TR-0172, (S6816-15)-1, The Aerospace Corporation, San Bernardino, California, December 1971, UNCLASSIFIED.
3. Schneider, P.J., Teter, R.D., Coleman, W.D., and Heath, R.M., "Design of Graphite Nostetips for Ballistics Reentry," Journal of Spacecraft and Rockets, September 1973, pp. 592-598.
4. Greenstreet, W.L., and Battle, G.C., Jr., Editors, Proceedings of the Conference on Continuum Aspects of Graphite Design (Gatlinburg, Tennessee, 9-12 November 1970), Oakridge National Laboratory, 70105, February 1972, CONFIDENTIAL.
5. Jarvis, A.F. and Jones, E.K., Microwave Engineering, 2nd ed., Vol 2, p. 632, Academic Press, New York, 1968.
6. Christiansen, D.H., "Integrated Circuits in Action," The Great Design Dilemma, Vol 39, pp. 68-87, 17 October 1968.
7. Kilner, J.R., Roughness Criteria for Bomb Damage Repair of Airfield Pavements, ESL-TR-77-30, Engineering and Services Laboratory, Air Force Engineering and Services Center, Tyndall AFB, Florida, April 1980, CONFIDENTIAL.
8. Dill, R.F., "Contemporary Soil Erosion," Ph.D Thesis, Florida State University, 1980.

NOTE: Classification markings are not needed if all publications on Reference List are unclassified.

Figure A-23. Sample Reference List.

APPENDIX A
REPAIR SPACING RESTRICTIONS DATA

NOTE: Appendix A must begin on
a right-hand page.

Figure A-24. Sample Appendix Cover Page.

APPENDIX A

REPAIR SPACING RESTRICTIONS DATA

This appendix presents data and instructions that may be used for construction of spacing requirement curves for F-4 aircraft. Tables A-1 through A-18 present takeoff performance data for the F-4E and F-4C/D at takeoff weights of 42,000, 47,000, and 57,000 pounds and air-density ratios (DRs) of 0.9, 1.0, and 1.1. Using maximum thrust (afterburners), the tables tabulate time, distance traveled from brake release point, the distance the aircraft will travel in the next 4 seconds and instantaneous aircraft speed. These data are used to construct the 4-second curves referenced in the following instructions.

Instructions are given for construction of spacing curves for use on unidirectional minimum operating strip (MOS) in Figure A-1. Bidirectional MOS spacing curves are constructed by reversing the unidirectional MOS curves (end-for-end) and superposing on the unreversed curves.

Figure A-25. Sample of Appendix.

TABLE A-11. TAKEOFF DATA F-4C/D AT 42,000 POUNDS, DR = 1.0 .

TIME (SEC)	DISTANCE (FEET)	TRAVEL IN 4 SECONDS (FEET)	VELOCITY (KIAS)
1.0	8	207	10
2.0	33	281	19
3.0	75	356	31
4.0	136	430	42
5.0	215	505	53
6.0	314	578	64
7.0	431	651	75
8.0	566	723	86
9.0	720	793	96
10.0	892	863	107
11.0	1082	931	118
12.0	1289	998	128
13.0	1513	1064	138
14.0	1755		148
14.5	1888		153
15.0	2013		158
16.0	2287		167
17.0	2577		176
17.1	2600		177

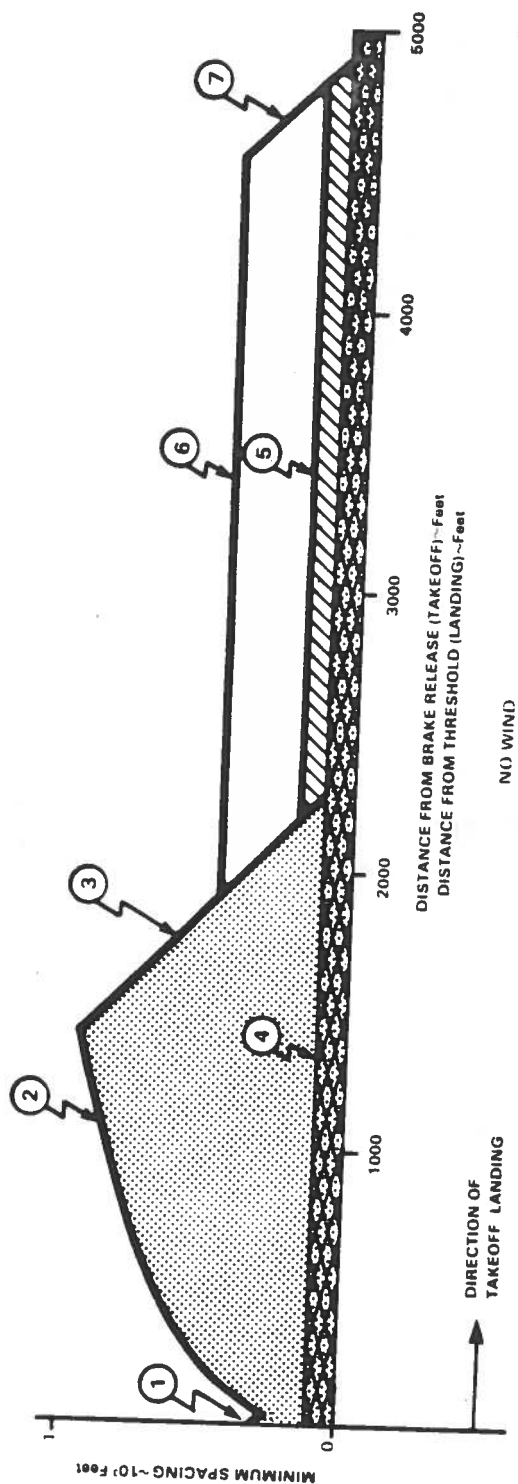
TIME = Total time elapsed from brake release

DISTANCE = Distance traveled from brake release

TRAVEL IN 4 SECONDS = Distance aircraft will travel in following 4 seconds

VELOCITY = Instantaneous aircraft speed

Figure A-26. Sample Appendix Table .



SEGMENT

CONSTRUCTION COMMENTS

- ① Drawn from point at zero distance, 300-foot spacing or (0,300) to point at 300 foot distance, zero-spacing or (300,0). Discontinues at intersection with Segment 2. Prevents impacting more than one repair prior to velocity of 60 knots on takeoff roll
- ② Four second takeoff curve constructed from values in Tables A 1 through A 18 Drawn from (0, 0) point, discontinues at intersections with Segments 1 and 3 Provides four seconds before impacting a second repair Allows response to first repair to be damped out
- ③ Drawn at 45° from (begin rotation, 0) point. Discontinues at intersection with Segment 4.
- ④ Constant 100-foot spacing. Prevents excitation of high frequency landing gear response.
- ⑤ Constant 200-foot spacing. Required, only for 3.0-inch high repairs with more than 0.5-inch nominal sag.
- ⑥ Constant 450-foot spacing. Required, only for 4.5-inch high repairs. (If either of repairs under consideration is a 3.0-inch high repair, the 200-foot spacing curve applies)
- ⑦ Drawn at 45° from (end of MOS, 0) point. Discontinues at intersection with Segment 4. If MOS extends more than 5,000 feet. Segments 5, 6, and 7 are adjusted to actual end. (SRCs is Section IV of the main body of this report do not show this segment as the actual MOS end is not known).

Figure A-1. Construction of F-4 Repair Space Curves

Figure A-27. Sample Appendix Figure.

INITIAL DISTRIBUTION

DTIC-DDA-2	2	WR-ALC/MMSH (2)	1
NMERI	1	WR-ALC/MMSRBA	1
AUL/LSE 71-249	1	WR-ALC/MMSF	1
HQ AFSC/DLWM	1	HQ MAC/DEM	1
HQ AFSC/SDNE	1	HQ MAC/DEP	1
HQ AFSC/TEVA	1	HQ MAC/XPQA	1
HQ USAFE/EUOPS (DEXD)	1	HQ AFESC/DEMP	1
HQ USAFE/DEX	1	HQ AFESC/DEO	1
3AF/XN	1	HQ AFESC/TST	1
AFFTC/TEOB	1	BDM Corp, McLean VA	1
AFFTC/ENAE	1	BDM Corp, Tyndall AFB	1
AFATL/DLJK	1	USA WES	1
AFATL/DLYW	1	HQ USAF/LEEX	1
AD/IN	1	HQ USAF/LEYW	1
USAFTAWC/THLA	1	HQ USAF/RDXP	1
AFATL/DLODL	1	AFWAL/FIBT	1
AFTEC/DET 2	1	AFWAL/FIEB	1
EOARD/LNS	1	AFWAL/FIEM	1
SHAPE Tech Cen, USRADCO	1	AFWAL/FIBE	1
OO-ALC/MMIRCLE	1	HQ AFLC/DEMG	1
OO-ALC/MMSRWF	1	AFIT/DET	1
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AFISC/IGQB	1	A&AEE MOD (P.E.)	1
US Navy Civil Engrg Lab	1	British Embassy (Wash.)	1
WR-ALC/MMS	1	Ministry of Defense (Pro.)	1
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Figure A-28. Sample Initial Distribution - Limited.

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HQ USAFE/DEMY	1	HQ USAF/LEYW	1
HQ USAFE/DEM	1	HQ USAF/RDPX	1
HQ USAFE/DEX	1	AFWAL/MMXE	1
HQ USAFE/EUROPS (DEXD)	1	AFWAL/FIEM	1
AFATL/DLJK	1	AFWAL/FIBE	1
AFATL/DLODL	1	HQ AFLC/DEMB	1
AD/IN	1	HQ AFLC/DEE	1
USAFETAWC/RX	1	AFIT/DET	1
USAFTAWC/THL	1	AFIT/LDE	1
USAFTAWC/THLA	1	EOARD/LNS	1
HQ PACAF/DEE	1	HQ PACAF/DEMM	1
HQ PACAF/DEM	1	HQ PACAF/DEPR	1
HQ TAC/DEE	1	HQ TAC/DRP	1
AFISC/IGQB	1	HQ SAC/DE	1
US Navy Civil Engrg Lab	1	HQ AFESC/DEMP	1
HQ AFESC/DEO	1	AUL/LSE 71-249	1
HQ AFESC/CC/CV/CA	1	HQ USAF/LEE	1

Figure A-29. Sample Initial Distribution - Unlimited.

HQ AFESC/RDXX
TYNDALL AFB, FL 32403

OFFICIAL BUSINESS

FOURTH CLASS

Figure A-30. Back Cover - Unlimited.

FEDERAL LABORATORY TECHNOLOGY APPLICATION ASSESSMENT



DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE ENGINEERING AND SERVICES CENTER
TYNDALL AIR FORCE BASE, FLORIDA 32403



AIRCRAFT SKIN PENETRATOR/AGENT APPLICATOR

A. OBJECTIVE

Purpose The objective of this effort was the development and construction of an aircraft skin penetrator/agent applicator device that would rapidly penetrate aircraft skin (3 to 7 seconds) and allow the placement of a suitable fire-suppressing agent onto the base of the fire for extinguishment.

B. SUMMARY

Need This work was initiated at the request of HQ MAC/DE, SAC/DE, and TAC/DE to develop, construct, and test a device for rapid penetration into burning aircraft interiors to extinguish fires. Effective attack and suppression of aircraft fires frequently require application of a fire-extinguishing agent to internal, enclosed spaces. Access to such spaces may often be severely limited because of the unavailability of doors and access ways. Current Air Force firefighting equipment does not provide for rapid access to aircraft fires which occur in airframe voids where access ports are either limited or not provided. Various aircraft sizes, configurations, and the use of high-strength metal alloys make forced entry to these areas time-consuming and difficult. Volume I discusses, in detail, the research conducted on the development of the proposed working model of the Aircraft Skin Penetrator/Agent Applicator. The report contains photographs of the different concepts considered. Volume II has detailed drawings showing the construction of the working model Penetrator and sketches which show how the Penetrator may be used to fight aircraft fires.

Product

C. STAGE OF DEVELOPMENT

This item has been tested and evaluated, using aircraft interior fires. Development is complete.

D. USER/PLANNED ACTION

Use HQ AFESC/DEF and the Major Air Commands will use this report and purchase description to initiate procurements of these tools for use by Air Force firefighters. The technical report and purchase description are being distributed to HQ AFESC/DEF and the Major Air Commands.

E. PATENT OR PROPRIETARY STATUS

No patent action will be taken. No proprietary rights to this research exist.

Figure A-31. Implementation Plan/Technology Transfer
(RD Form 16).

F. APPLICATION TO DOD/GOVT CIVILIAN AGENCIES

Possible use for fighting aircraft fires in both military and civilian environments.

G. PUBLICATIONS

R. H. Cuthbertson, Aircraft Skin Penetrator and Agent Applicator, Volume I and II, ESL TR-84-12, November 1984.

H. ADDITIONAL INFORMATION

J. Walker, Chief, Fire Technology Branch, Engineering Research Division/
HQ Air Force Engineering and Services Center, Tyndall AFB FL 32403, Telephone
904/283-6451. Request copies of publication from NTIS.

JOSEPH L. WALKER
Chief, Fire Technology Branch

ROBERT E. BOYER, Col, USAF
Director, Engineering and
Services Laboratory

EVERETT L. MABRY, Lt Col, USAF
Chief, Engineering Research
Division

CHECKLIST FOR R&D FORM 16

A. OBJECTIVE

1. What was the goal of this research/development?
2. Were there subobjectives? If so, what were they?

B. SUMMARY

1. Why was the R&D needed?
 - a. Who requested it?
 - b. What problem did it address?
 - c. Why was the problem there?
 - d. What efforts had been made to solve it?
2. What did we do?
 - a. What was our approach?
 - b. What was the scope of our research?
 - c. Did we solve the problem?
 - d. What remains to be done?
3. What information is contained in the report?

C. User/Planned Action

1. Will we use the R&D as a basis for followup work? If so what have we planned and when? If no followup is planned, why not?
2. Can MAJCOMs use the technology? How? How can we help them? What software or equipment will they need? Who will write implementing directives?
3. Can other services use it? How? How do we transfer it?
4. Can non-DOD agencies or civilians use it? If so, how will technology transfer be achieved? If technology transfer is not possible or if technology is of limited value outside DOD, say so and give the reason.

NOTE: Remember this Implementation Plan must give the Director (and AFESC Commander) a clear, concise picture of what your technology effort is about and how it may be used.

Figure A-32. Checklist for R&D Form 16.



DEPARTMENT OF THE AIR FORCE
HEADQUARTERS AIR FORCE ENGINEERING AND SERVICES CENTER
TYNDALL AIR FORCE BASE, FL 32403

(Date)

REPLY TO
ATTN OF: RDXI (Mr Testerman)

SUBJECT: Request for Security and Policy Review (IAW AFR 190-1)

TO: PA

1. Request the following document be reviewed for public release in accordance with Air Force Security and Policy review procedures as outlined in AFR 190-1: Development of an Optimum Rescue Tool.
2. If approved for release, the specific time, place and audience will be: Approved for public release. Distribution unlimited.
3. To the best of my knowledge, the release of this document is consistent with current Air Force policy. I certify this document has been reviewed by competent technical authority, and that it is accurate, unclassified, clear of all proprietary and copyright restrictions, and is suitable for public release.

LARRY L. TESTERMAN
Technical Editor

1st Ind, HQ AFESC/PA

To:

The document cited above is:

- () a. Approved for release to the public.
- () b. Approved for release to the public, subject to the following conditions:

- () Not approved for release at this level. Please provide six copies for review by SAF/PAS.
- () Not approved for release to the public.

JAMES H. HEABERG, Maj., USAF
Director, Public Affairs

Figure A-33. Policy and Security Review Letter (for Unlimited Distribution).

APPENDIX B

ESL STYLE GUIDE

A. INTRODUCTION

The information in this Appendix has been selected from a variety of sources, including the authors' experience, and should prove helpful to those who write and edit TRs. Although many approaches to technical style exist, this section presents ESL preference. We hope that it will help in clarifying past and present problem areas for authors and project officers.

B. GENERAL STYLE

Although technical style differs from ordinary style, the rules of grammar, punctuation and usage still apply. Style manuals, dictionaries, and basic English textbooks are invaluable tools for technical writers. For a short listing of sources, with commentary, see the Annotated Bibliography. A few of the more common rules of punctuation, grammar, and usage will be presented here. The following rules are not all-inclusive but have special application to technical and scientific writing.

C. PUNCTUATION

1. Commas

a. A comma goes before "and" or "or" in a series of three or more:

° SN, K, Na, and Li lines are invisible.

b. Write dates as follows, without commas:

° 23 March 1976

c. A comma is used in a compound sentence with a coordinating conjunction (and, but, or, nor, for, only) and between the independent clauses of a compound sentence to let the reader know that one clause is ending and the next one beginning.

° He hurriedly conducted the vibration test, for the research team was anxious to know the results.

d. A comma is used to introduce lists or explanations. Commas are now generally used to enclose such words as, for example (e.g.), that is (i.e.), namely, etc., when they are followed by words or phrases, but not by independent clauses (independent clauses require the semicolon).

- ° Our course in mechanical engineering prepares the student for any of the various branches of the profession, i.e., engine design, automatic design, locomotive construction, etc.

But:

- ° The satellite is essentially a moving tower in space; that is, it provides a point to intercept, amplify, and relay signals that would otherwise soar off into the cosmos.

e. A comma is used for:

(1) Interpolated matter (so-called parenthetical expressions). These can be words, phrases, or clauses.

- ° These modifications, however, will have to be approved by the commander.
- ° The computerized model, I regret to say, proved unacceptable for obtaining data.

NOTE: If the connection is so close that the inserted matter does not interrupt the continuity of the sentence, no commas are needed. In other words, you will have either two commas or none.

- ° He was perhaps too busy to notice.
- ° Let me know when and if that happens.

(2) Nonrestrictive clauses and phrases. These are subordinate clauses and phrases (usually relative clauses) which merely serve to give additional information about or a description of someone or something; they must be set off by commas. A restrictive clause or phrase, on the other hand, cannot be set off by commas because it is absolutely necessary to the basic meaning of the sentence.

- ° Precession, which causes the gyro rotor to be displaced 90 degrees from the applied force, is a critical factor in missile design. (Non-restrictive)
- ° The company that has the best production facilities will get our business. (Restrictive)

- ° The following components are discussed: (1) antennas, (2) transmitters, (3) duplexers, (4) converters, and (5) autopilots.

c. Punctuation in parentheses. Punctuation marks belonging to the parenthetical expression go inside the parentheses; those belonging to the rest of the sentence go outside. When a parenthetical expression comes at the end of a sentence and is part of the sentence, put the period outside. But if the expression is really independent of the sentence, make a separate sentence of it and enclose it all in the parentheses.

- ° The receiver operates in a conventional manner (Reference 2).
- ° The receiver operates in a conventional manner. (Receivers are discussed under C.)

4. Semicolon (;)

a. Compound sentences. In this application, think of the semicolon as a "semiperiod." Use it without conjunctions whenever you wish the reader to know that you are combining two or more independent sentences into one compound sentence because the ideas expressed are so closely related as to form one idea.

- ° A plane or missile traveling at the speed of sound has a flight speed of Mach 1.0; if it travels at twice the speed of sound, its flight speed is Mach 2.0.
- ° Fission is the splitting of a heavy atomic nucleus; fusion is the union of lightweight atomic nuclei.

b. A semicolon is used in:

Clauses, phrases, and series containing commas and conjunctions to separate clauses, phrases, or items in a series if there is a comma in one or more of these elements.

- ° A great deal of controversy, much of it on the part of laymen, has existed concerning the interpretation of certain fine, line-like markings on the planet Mars; and even today, after more than half a century of such discussion, we do not know their true nature.

NOTE: THIS IS NOT GOOD WRITING! A BETTER EFFORT WOULD MAKE TWO SENTENCES OF THE ABOVE HODGEPODGE.

- ° Letters have been received from Turin, Italy; Bordeaux, France; Liverpool, England; Brooks AFB, TX; Tyndall AFB, FL; and Maxwell AFB, AL.

c. A semicolon is also used before a conjunctive adverb or other transitional or connective words. Use the semicolon to separate two independent clauses (but not phrases) when the second clause is introduced by a connective (transitional) word or phrase such as accordingly, consequently, for example (e.g.), however, on the contrary, that is (i.e.), therefore, etc. A comma may be placed after the connective word to stress the separation.

- ° He corrected the interference problem; however, he did not explain the errors in the evaluation system.
- ° Try to punctuate correctly; for example, avoid comma blunders!
- ° There is a great deal of difference between the prefixed macro- and micro-; that is macro means large, and micro means small.

For other forms of punctuation and more specific usage, consult any style guide or English textbook.

D. NUMBERS

Numbers at the beginning of a sentence are always spelled out.

In text, spell out numbers one through nine, use numerals for 10 and over. Use numerals involving a group of two or more related numbers in which any one is 10 or more:

- ° The capacitor has 3 leads, 2 pairs of controls, and 12 settings.
- ° The set included eight pressure transducers (five Kulite and three bar gages).
- ° The set included 25 pressure transducers (15 from Test A and 10 from Test B).
- ° The fourth anchor bolt the 10th anchor bolt.

Numbers under 10 preceding a unit modifier containing a number are spelled out; unless the unit modifier expresses a unit of measurement, time, money or percent.

- ° three four-pole switches
- ° one 10-channel magnetic spectrometer
- ° 120 three-way experimental switches
- ° one 3-inch board

Units of measurement, money, time, and percent are expressed in numerals, regardless of size.

- 1 inch
- 5 dollars
- 2 milliseconds
- 1 micrometer
- 3 percent

Decimal points should be preceded by a unit digit.

- 0.25 kilometer

For an inclusive range of numbers, use the following patterns:

- Figures 1-10
- pages 352-357
- 1906-1938

Plurals of numerals will be expressed by adding a lower case "s" without an apostrophe.

- 6s
- The 1980s

Small fractions such as one-half, one-fourth or one-tenth, will be spelled out unless they are written with a unit of measure, while larger fractions such as $1/32$ will be expressed in numerals. The oblique line or shilling mark / will be used in fractional expressions.

- | | |
|--------------|--------------------------|
| ◦ Two-thirds | ◦ $3 \frac{3}{4}$ pounds |
| ◦ $3/4$ inch | ◦ $2/3$ meter |
| ◦ $28/32$ | |

When numbers are used as compound unit modifiers a hyphen will be required if the unit of measurement is spelled out.

- ° a 10-meter lane ° a 12-inch board
- ° a five-step test ° a 2- by 5-inch board

But not if the unit is abbreviated:

- ° a 35 mm slide ° a 2 hr wait
- ° a 10 ml flask ° a 6 amp fuse

If two unrelated numbers are used together in a sentence, the smaller one will be spelled out.

- ° 1500 sixty-cycle motors

Numbers used in dates and designations will be expressed as follows:

- ° 4th of June ° FY 83
- ° June 4th, 1982 ° 4 June 1982 (military)
- ° 1st Army ° June 1982
- ° 13th Air Force ° Zone 7
- ° Test 1, Test 2 ° Reference 3

Other examples:

- ° three capacitors ° 10 by 10 mm
- ° four strain tests ° 1/2-inch diameter pipe
- ° 2 to 1 ° 6 hours 4 minutes 20 seconds
- ° Tests 5 and 6 ° 2:1
- ° the seventies ° \$2 to 3 million
- ° 15K

E. WORD COMPOUNDING (HYPHENATION)

Unnecessary hyphenation should be avoided in scientific and technical writing. The Government Printing Office Style Manual's section on compound words is a primary source; Webster's Third International Dictionary, The Chicago Manual of Style, and the McGraw-Hill Scientific Dictionary also provide excellent guidance, as does Look It Up by Rudolph Flesch.

In general, words prefixed by anti, bi, bio, counter, extra, infra, inter, intra, macro, micro, mid, mini, multi, non, over, post (after), pre, pro, pseudo, re, semi, sub, super, supra, trans, ultra, un, and under form a single word with the word they precede, except where this word is a proper adjective (non-Cambrian, multi-European) or where the word without a hyphen is clearly awkward (multi-integrated).

Some prefixed words and word combinations always require a hyphen. Examples are words prefixed by self- and quasi-, or words such as un-ionizing, man-hours, co-worker.

Other word combinations or prefixes are not so clearly defined and depend on usage. A great deal of confusion and inconsistency can be avoided by using the following combinations as one word (authorized by GPO Style Manual): firefighter, postattack, ongoing, setscrew, capscrew, downtime, eyewitness, airbase, landmine, minesweeping (takeoff, setup, warmup, shutoff, cleanup, buildup, and checkout when not used as verbs), and others. If the writer accepts the GPO designation as one word, the usage is consistent and the question of whether to hyphenate does not arise. (For further guidance see Appendix C.)

NOTE: The Government Printing Office Style Manual will be the primary source book for word compounding in ESL TRs.

F. SIMPLER WORDS AND PHRASES

Technical writing does not demand vague words and fancy phrases, nor does it require "jargonized" mumblespeak. Write naturally--in the words you speak with--a simple, direct style. The essence of English is in its short, concrete words that save valuable reading time while improving the vigor of your writing and the clarity of your ideas. Your subject matter will provide the large words. The following list comes from AFR 5-31 and from a list compiled by Robert A. Day in How To Write And Publish A Scientific Paper.

<u>Word or Phrase</u>	<u>Preferred Usage</u>	<u>Word or Phrase</u>	<u>Preferred Usage</u>
accomplish	carry out, do	in accordance with	by, under
accomplish (a form)	fill out, complete	in addition	also, too
accounted for by the fact	because	in a number of cases	some
adjacent to	next to	in a position to	can, may
afford an opportunity	allow, let	in a satisfactory manner	satisfactorily
along the lines of	like	in a very real sense	in a sense or leave out
a majority of	most		to
a number of	many	in an effort to	since, because
an order of magnitude	10 times faster	inasmuch as	if
are of the same opinion	agree	in case	with
as a consequence of	because	in conjunction with	about, concerning
as a matter of fact	in fact or leave out	in connection with	blend, join, merge
as can be seen	Leave out or use sparingly	incorporate	start, begin
	under	initiate	instead of
as prescribed by	as happens	in lieu of	I think
as is the case	as happens	in my opinion it is not an unjustifiable assumption that	for, so
as of this date	today		to
assist, assistance	aid, help	in order that	about, concerning
as to	about or leave out	in order to	toward, to
attached herewith is	here is	in regard to	about
attempt	try	in relation to	sometimes
at the present time	now	in respect to	only as noun or adjective, not verb
at an earlier date	previously	in some cases	about
at this point in time	now	interface	soon
			if
based on the fact that	because	in terms of	has, have
		in the near future	because, since
completely full	full	in the event that	is
close proximity	near	in the possession of	Smith reported
component part	part or component	in view of	I haven't bothered to look up the reference
confront	face, meet	is defined as	apparently
consequently	so	it has been reported by Smith	I think
constitutes	is, forms, makes up	it has long been known that	clearly
deem	think	it is apparent that	I do not understand it
demonstrate	prove, show	it is believed that	possibly
demonstrates the		it is clear that	a product
substantiation of	prove	it is clear that much additional work will be required before a complete understanding	leave out
definitely proved	proved	it is doubtful that	often
despite the fact that	although	it is evident that a product	I think, suggest
during the course of	during, while	it is of interest to note that	
desire	wish	it is often the case that	note that
disclose	show	it is suggested that	maybe
due to	because of, from	it is worth pointing out in this context that	but
due to the fact that	since, because	it may be that	leave out
		it may, however, be noted that	
elucidate	explain	it should be noted that	
end result	result		
effect a change	make a change, change	lacked the ability to	could not
employ	use	large in size	large
endeavor	try	let me make one thing	
equivalent	equal	perfectly clear	a snow job is coming
establish	set up, prove, show	location	place, scene, site
evidenced	showed		
evident	clear	magnitude	size
exhibit	show	maintain	keep, support
expedite	hurry, rush, speed up	maximum	greatest, largest, most
expedition	fast, quick	militate against	prohibit
explain	show, tell	minimize	reduce, decrease, lessen
			change
fabricate	make	modify	check, watch
fewer in number	fewer	monitor	
first of all	first		
for the purpose of	for	needless to say	leave out, and leave out whatever follows it
for the reason that	since, because	numerous	many, most
facilitate	ease, help		
finalize	complete, finish	of great theoretical and practical importance	useful
forward	send	on account of	because
		on behalf of	for
give rise to	cause	on the basis of	by
		on the grounds that	since, because
has the capability of	can		
having regard to	about		
herein	here		
impacted	changed, hit		
implement	carry out, do, follow		

<u>Word or Phrase</u>	<u>Preferred Usage</u>	<u>Word or Phrase</u>	<u>Preferred Usage</u>
on the part of our attention has been called to the fact that owing to the fact that	by, among, for we discovered since, because	take into consideration that terminate the great majority of the opinion is advanced that therefore there are there is this result would seem to indicate through the use of transpire	consider end most I think so avoid avoid this result indicates by, with happen, occur
pertaining to pooled together prioritize promulgate provide provided that provides guidance for	about, of pooled rank announce, issue give, supply if guides	ultimate until such time as utilize, utilization	last, final until use
quite unique	unique		
reason for recapitulate regarding rather interesting red in color referred to as relative to relating to remuneration render smaller in size solicit submit subsequent subsequently substantial sufficient	why sum up about, of interesting red called about about, on pay give, make smaller ask for give, send later, next after, later, then large, real, strong enough	verbatim via viable was of the opinion that ways and means we wish to thank whereas whether or not with a view to with reference to with regard to with respect to with the result that with reference to with the exception of with the possible exception of	word for word, exact in, on, through workable believed ways, means not both we thank since whether to about or leave out concerning, about (or leave out about so that about except for except

G. UNITS OF MEASUREMENT

Measurement units in many AFESC TRs, particularly those published for the international scientific community, are preferred to be in the International System of Units, generally known as SI. This system is a modern version of the MKSA (meter, kilogram, second, ampere) system. The ASTM Standard for Metric Practice, is a non-Government standard approved for use by agencies of the Department of Defense for listing in the DOD Index of Specifications and Standards.

NOTE: Exceptions to the above requirement may be made when the R&D effort in question interacts with existing Air Force systems based on the English measurement system or when needed for clarity or readability.

Do not mix the metric and English systems in the same report. It might be helpful to provide the metric (or English) equivalent in parentheses or prepare a conversion scale.

Units of measurement that are short and not compound words will be spelled out when used in text (inch, foot, meter, yard, minute, second, liter, gram, pound, knot, mile, etc.).

Use numerals to express measurements; e.g., 1 inch, 4 days, 1 pound, 1/2 ton, -0.24 volt, 2 hours, etc., regardless of size.

Capitalize symbols for units derived from proper names (dB, Hz, N, J); use lower case if derived from a proper name and spelled out (decibel, hertz, newton, joule).

H. ABBREVIATIONS

The following composite list of scientific and technical abbreviations is provided for your use. If you use a nonlisted or nonstandard abbreviation, spell it out the first time used. For the reader's benefit, when in doubt, spell it out.

<u>Word or Unit</u>	<u>Abbreviation</u>	<u>Word or Unit</u>	<u>Abbreviation</u>
alternating-current	ac	degree Fahrenheit	°F
altitude	alt	degree kelvin	°K
ampere	a, amp, A	degree rankine	°R
ampere-hour	Ah	Department of Defense	DOD
ampere per meter	A/m	direct current	dc
amplitude modulation	AM	disintegrations per minute	dis/min
angstrom	Å	disintegrations per second	dis/s, dis/sec
ante meridiem	a.m.	east	E
antilogarithm	antilog	edition	ed.
aperture ratio 16	f/16	electromagnetic unit	emu
atmosphere	atm	electromotive force	emf
atomic	at.	electrons per atom	e/at.
atomic mass unit	amu	electrons per cubic centimeter	e/cm ³
atomic percent	at. %	electron unit	e.u.
atomic unit	a.u.	electronvolt	eV
atomic weight	at. wt	electronstatic unit	esu
audio-frequency	af	et ali (and others)	et al.
azimuth	az	exempli gratia (for example)	e.g.
		exponential	e, exp
barrel	bbl		
bel	B	farad	F
billion electron volt		feet per minute	ft/min
(obsolete)	use GeV	feet per second	ft/s
boiling point	bp	feet per second squared	ft/s ²
British thermal unit	Btu	foot	ft
		footcandle	fc
Calorie (large)	Cal	footlambert	fL
calorie (small)	cal	foot pound	ft-lb
candela (candle obsolete)	cd	foot pound-force	ft-lbf
candela per square meter	cd/m ²	frequency modulation	FM
candlepower	cp		
centigram	cg	gallon	gal
centimeter	cm	gallon per minute	gal/min, gpm
centimeter per second	cm/s	gallon per second	gal/s
cologarithm	colog	gauss	G
confer (compare)	cf.	gigacycle	Gc
continuous-wave	cw	gigaelectronvolt	GeV
cosine	cos	gigacycles per second	spell out
cosine, hyperbolic	cosh	gigahertz	GHz
cotangent	cot	gigavolt	GV
coulumb	C	gram	g
cubic	cu	gram-atom	g-at.
cubic centimeter (liquid)	cc	gram-atomic-weight	g-at. wt
cubic centimeter (volume)	cm ³	gram-calorie	g-cal
cubic foot	ft ³	gram equivalent weight	gew
cubic foot per minute	ft ³ /min	gram formula weight	gfw
cubic foot per second	ft ³ /s	gradient	grad
cubic inch	in. ³		
cubic kilometer	km ³	hectare	ha
cubic meter	m ³	hectogram	hg (define)
cubic micrometer	m ³ use prefix for	henry	H
	micro	hertz	Hz
cubic millimeter	mm ³	high frequency	HF
curie	Ci	horsepower	hp
cycle per second,		hour	h
vibratory (obsolete)	see Hz		
		ibidem (in the same place)	ibid.
decibel	dB	id est (that is)	i.e.
degree (angular)	deg	inch	in.
degree (latitude/longitude)	°	inch per second	in./s
degree Celsius (Centigrade)	°C	inch pound	in.-lb

<u>Word or Unit</u>	<u>Abbreviation</u>	<u>Word or Unit</u>	<u>Abbreviation</u>
incorporated	Inc.	microsecond	μ s
intermediate frequency	IF	micros of mercury	μ Hg
international angstrom	IA	microvolt	μ V
		microwatt	μ W
joule	J	mile	mi
		mile per hour	mi/h, mph
kelvin	K	milli- (prefix, 10^{-3})	m
kilobar	kbar	milliamper	mA
kilocalorie	kcal	millibar	mbar
kilocycle	kc	millicurie	mCi
kiloelectronvolt	keV	millielectronvolt	meV
kilocycles per second	kHz, kc/s, kc/sec	millifarad	mF
kilogauss	kG	milligauss	mG
kilogram	kg	milligram	mg
kilogram-calorie	kg-cal	millihertz	mHz
kilogram-force	kgf	milliliter	ml
kilogram-meter	kg-m	millimeter	mm
kilogram per cubic meter	kg/m	millimeters of mercury	mm Hg
kilogram per second	kg/s	millimicron (obsolete)	nm (nanometer)
kilohertz	kHz	milliroentgen	mR
kilohm	k	millisecond	ms
kilojoule	kJ	millitorr	mtorr
kilokelvin	°K	millivolt	mV
kiloliter	kl	millivolt per cycle	mV/c
kilometer	km	milliwatt	mW
kiloton	kt	minute (time)	min
kilovolt	kV	minute (plane angle)	'
kilovoltampere	kVA	molal (concentration)	m
kilovolt peak	kVp	molar (concentration)	M
kilowatt	kW	molecule	mol
kilowatt hour	kWh	molecular orbital	MO
kips per square inch	k/in. ²	molecular weight	mol wt
knot	spell out	month	mo
lambert	L	nanometer	nm
langmuir	L (define)	nanosecond	ns
latitude	lat	nautical mile	nmi
linear	lin	newton	N
linear foot	lin ft	normal (concentration)	N
liter	L	north	N
logarithm	log		
logarithm (natural, base e)	ln	oersted	Oe (use of A/m amperes per meter preferred)
low frequency	lf		Ω
lumen	lm	ohm	Ω
lumen per watt	lm/W	ohm centimeter	Ω cm
		ohms per square	Ω /sq
mark	mk	ounce	oz
mean effective pressure	MEP	ounce-foot	oz-ft
mean point of impact	MPI	ounce-inch	oz-in.
mean sea level	MSL		
medium frequency	MF		
megacycle	Mc	page	p.
megacycles per second	MHz, Mc/s, Mc/sec	pages	pp.
megaelectronvolt	MeV	parts per million	p/m, ppm
megahertz	MHz	pascal	Pa
megarad	Mrad	picofarad	pF
megaton	Mt	picosecond	ps, psec
megavolt	MV	pint	pt
megawatt	MW	post meridiem	p.m.
megohm	M Ω	pound	lb
melting point	mp	pound-foot	lb-ft
meter	m	pound-force	lbf
meter-kilogram-second (system)	mks	pound-force per square inch	lbf/in. ²
meters of water equivalent	mwe, m(w.e.) (define)	pound per cubic foot	lb/ft ³
	MA	pound per square foot	lb/ft ²
microampere	μ A	pound per square inch	lb/in. ²
microampere hour	μ A·h, A h	pound per square inch absol	lb/in. ² a
microfarad	μ F	pound per square inch gauge	lb/in. ² g
microcoulomb	μ C	pulse per second	p/s
microgram	μ g		
microhm	μ Ω	quantum electrodynamics	QED
micrometer	μ m	quart	qt
micron	μ		
micropascal	μ Pa		

<u>Word or Unit</u>	<u>Abbreviation</u>	<u>Word or Unit</u>	<u>Abbreviation</u>
radian	rad	very low frequency	VLF
radio-frequency	rf	videlicet (that is to say, namely)	viz.
revolutions per minute	r/min or rpm	volt	V
revolutions per second	r/s, rps	voltampere	VA
roentgen	R	voltampere reactive	Var
root mean square	rms	volume	vol
		volume percent	vol %
second (time)	s	watt	W
second-foot	s-ft	watthour	Wh
south	S	watt per steradian	W/sr
specific gravity	sp. gr.	weber	Wb
specific heat	sp. ht.	webers per square meter	Wb/m ²
specific volume	sp vol	weight	wt
square	sq	weight percent	wt %
square centimeter	cm ²	west	W
square foot	ft ²	yard	yd
square inch	in. ²		
square kilometer	km ²		
square meter	m ²		
square micrometer	μm ²		
square mile	mi ²		
square millimeter	mm ²		
square yard	yd ²		
standard	std		
standard temperature and pressure	STP		
steradian	sr		
System International	SI		
tangent	tan		
telemetry	TM		
temperature	temp		
tera-electron-volt	TeV		
terahertz	THz		
tesla	T		
townsend	Td (define)		
ultrahigh frequency	UHF		
ultraviolet	uv		
unified atomic mass unit	u		
valence band	VB		
versus	vs		
very high frequency	VHF		

I. OTHER SCIENTIFIC ABBREVIATIONS

<u>Term</u>	<u>Abbreviation or Symbol</u>	<u>Term</u>	<u>Abbreviation or Symbol</u>
adenosine 5'-diphosphate	ADP	nicotinamide adenine	
adenosine 5'-monophosphate	AMP	donucleotide	NAD
adenosine 5'-triphosphate	ATP	nicotinamide adenine	
adenosinetriphosphatase	ATPase	dinucleotide (reduced)	NADH
biochemical oxygen demand	BOD	optical density	OD
central nervous system	CNS	red blood cells (erythrocytes)	RBC
cytidine 5'-diphosphate	CDP	reticuloendothelial system	RES
cytidine 5'-monophosphate	CMP	ribonuclease	RNase
cytidine 5'-triphosphate	CTP	ribonucleic acid	RNA
deoxyribonuclease	DNase	ribose	Rib
deoxyribonucleic acid	DNA	ribosomal ribonucleic acid	rRNA
depxuirdome monophosphate	dUMP	standard deviation	SD
diethylaminoethyl cellulose	DEAE-cellulose	standard error	SE
ethylendiaminetetraacetate	EDTA	tonne (metric ton)	t
flavin adenine dinucleotide	FAD	transfer ribonucleic acid	tRNA
flavin mononucleotide	FMN	tris(hydroxymethyl)aminomethane	Tris
guanosine 5'-diphosphate	GDP	tyrosinyl	Tyr
messenger ribonucleic acid	mRNA	uracil	Ura
methyl	Me	uridine 5'-diphosphate	UDP
milliequivalent	meq	white blood cells (leukocytes)	WBC
minimum lethal dose	MLD	xanthine	Xan
		xanthosine	Xao
		xanthosine 5'-diphosphate	XDP

I. METRIC SYSTEM/SYSTEM INTERNATIONALE (SI)

A scientist will note measurements in equations, formulas, and tables according to the standard metric system. In this system, for example, a meter (m) is the base unit for measuring length and distance; a gram (g) is the base unit for measuring mass and weight.

The International System of units (SI) is the modern form of the metric system now being adopted throughout the world and explained in Standard For Metric Practice, American Society for Testing and Materials (ASTM). Prefixes and SI Units and Symbols are briefly discussed here. Authors needing more information and conversion factors are referred to ASTM Standard For Metric Practice.

1. Prefixes in The Metric System

A prefix is combined with any base unit to designate value of that particular unit. In the partial list below, notice that the prefix kilo means 1000 times the unit. Rather than write "1000 grams," a scientist will note this as "1 kilogram (1 kg)." And, instead of "1/1000th of a gram," he will write "1 milligram (1 mg)."

atto(a)	= 0.000000000000000001	= 10^{-18}
femto(f)	= 0.000000000000001	= 10^{-15}
pico(p)	= 0.000000000001	= 10^{-12}
nano(n)	= 0.000000001	= 10^{-9}
micro()	= 0.000001	= 10^{-6}
milli(m)	= 0.001	= 10^{-3}
centi(c)	= 0.01	= 10^{-2}
deci(d)	= 0.1	= 10^{-1}
deca(dk)	= 10	= 10^1
hecto(h)	= 100	= 10^2
kilo(k)	= 1,000	= 10^3
mega(M)	= 1,000,000	= 10^6
giga(G)	= 1,000,000,000	= 10^9
tera(T)	= 1,000,000,000,000	= 10^{12}

With this system, double prefixes are unnecessary. For example, rather than writing micromicrofarad (F), a mathematician or physicist will designate the value as picofarad(pF).

A prefix is considered as one term when combined with a base unit and so is not hyphenated. Initial capital letters are necessary only when the term begins a sentence.

SI symbols are written in singular form; unabbreviated SI units form their plurals in the same manner as other units of measure

2. SI Units and Symbols

a. Base Units: SI is based on seven well-defined units, which, by convention, are regarded as dimensionally independent:

<u>QUANTITY</u>	<u>UNIT</u>	<u>SYMBOL</u>
length	meter	m
mass	kilogram	kg
time	second	s
electric current	ampere	A
thermodynamic temperature	kelvin	K
amount of substance	mole	mol
luminous intensity	candela	cd

3. Supplementary Units: The units listed below are called supplementary units and may be regarded either as base units or as derived units.

<u>QUANTITY</u>	<u>UNIT</u>	<u>SYMBOL</u>
plane angle	radian	rad
solid angle	steradian	sr

4. Derived Units: These are formed by combining base units, supplementary units and other derived units according to the algebraic relations linking the corresponding quantities. The symbols for derived units are obtained by means of the mathematical signs for multiplication, division and use of exponents. For example the SI unit for velocity is the meter per second (m/s or $\text{m}\cdot\text{s}^{-1}$) and that for angular velocity is the radian per second (rad/s or $\text{rad}\cdot\text{s}^{-1}$). Those derived SI units which have special names and symbols are listed below:

<u>QUANTITY</u>	<u>UNIT</u>	<u>SYMBOL</u>	<u>FORMULA</u>
frequency (of a periodic phenomenon)	hertz	Hz	$1/\text{s}$
force	newton	N	$\text{kg}\cdot\text{m}/\text{s}^2$
pressure, stress	pascal	Pa	N/m^2
energy, work			
quantity of heat	joule	J	$\text{N}\cdot\text{m}$
power, radiant flux	watt	W	J/s
quantity of electricity,			
electric charge	coulomb	C	$\text{A}\cdot\text{s}$
electric potential			
potential difference, electromotive force	volt	V	W/A

<u>QUANTITY</u>	<u>UNIT</u>	<u>SYMBOL</u>	<u>FORMULA</u>
capacitance	farad	F	C/V
electric resistance	ohm	Ω	V/A
conductance	siemens	S	A/V
magnetic flux	weber	Wb	V·s
magnetic flux density	tesla	T	Wb/m ²
inductance	henry	H	Wb/A
luminous flux	lumen	lm	cd·sr
illuminance	lux	lx	lm/m ²
activity (of radionuclides)	becquerel	Bq	1/s
absorbed dose	gray	Gy	J/kg

OR

<u>QUANTITY</u>	<u>UNIT *</u>	<u>SYMBOL</u>
acceleration	metre per second squared	m/s ²
angular acceleration	radian per second squared	rad/s ²
angular velocity	radian per second	rad/s
area	square metre	m ²
concentration (of amount of substance)	mole per cubic metre	mol/m ³
current density	ampere per square metre	A/m ²
density, mass	kilogram per cubic metre	kg/m ³
electric charge density	coulomb per cubic metre	C/m ³
electric field strength	volt per metre	V/m
electric flux density	coulomb per square metre	C/m ²
energy density	joule per cubic metre	J/m ³
entropy	joule per kelvin	J/K
heat capacity	joule per kelvin	J/K
heat flux density	watt per square metre	W/m ²
irradiance	candela per square metre	cd/m ²
luminance	ampere per metre	A/m
magnetic field strength	joule per mole	J/mol
molar energy	joule per mole kelvin	J/(mol·K)
molar entropy	joule per mole kelvin	J/(mol·K)
molar heat capacity	newton metre	N·m
moment of force	henry per metre	H/m
permeability	farad per metre	F/m
permittivity	watt per square metre steradian	W/(m ² ·sr)
radiance	watt per steradian	W/sr
radiant intensity	joule per kilogram kelvin	J/(kg·K)
specific heat capacity	joule per kilogram	J/kg
specific energy	joule per kilogram kelvin	J/(kg·K)
specific entropy	cubic metre per kilogram	m ³ /kg
specific volume	newton per metre	N/m
surface tension	watt per metre kelvin	W/(m·K)
thermal conductivity	metre per second	m/s
velocity	pascal second	Pa·s
viscosity, dynamic	square metre per second	m ² /s
viscosity, kinematic	cubic metre	m ³
volume	l per metre	l/m
wavenumber		

* According to ASTM, metre and litre are the preferred spellings. In ESL Technical Reports, however, the more Americanized spellings of meter and liter are preferred.

Some terms can be abbreviated in several ways, depending on whose text you read. Preferred sources for ESL TRs are The Government Printing Office Style Manual, ASTM Standard For Metric Practice, MIL-STD-12, or other sources accepted by the Scientific and Engineering community. The objective is to avoid confusing the reader.

J. FORMAT FOR CITATION OF REFERENCES (5.5.1)

<u>Citation</u>	<u>Order of Elements</u>	<u>Example</u>
Book	Author(s), <u>title</u> , edition, volume(s), pages cited, publisher, place of publication, date	Jarvis, A.F. and Jones, E.K., <u>Microwave Engineering</u> , 2nd ed., vol 2, p. 632, Academic Press, New York, 1968
Periodical	Author(s), "title of article," <u>title of periodical</u> , volume, pages cited, date.	Christiansen, D.H., "Integrated Circuits in Action," <u>The Great Design Dilemma</u> , vol 39, pp. 68-87, 17 October 1968.
Technical Reports	Author(s), <u>title</u> , report number, place of publication, date, security classifica- tion, if applicable	Kilner, J.R. <u>Roughness Criteria for Bomb Damage Repair of Airfield Pavements</u> , ESL-TR-77-30, Engineering and Services Laboratory, Air Force Engineering and Services Center, Tyndall AFB Florida, April 1980, CONFIDENTIAL
Papers	Author(s), "title," event, place, date	Brauer, N.B., "Microelectronics for Command Systems," paper presented at Tenth American Ordnance Association Symposium, Bangor, Maine, 9 May 1979.
Thesis	Author, "title," thesis note, date	Dill, R.F., "Contemporary Soil Erosion," Ph.D Thesis, Florida State University, 1980.
Letters	Source, security classification, file number(s), addressee subject, date	Air Force Systems Command Secret Letter, AFSC 0331, AFESC/RD Subject: Request for Research Objectives, 12 May 1980.

Regulation
Specification
or Directive

Source, type of
publication, number
title, date

Air Force Manual 93-3,
Soil Erosion Control,
24 February 1965.

NOTE: References will be listed numerically, according to their order in the text. Bibliographies, however, will be compiled in alphabetical order. See sample Reference List and Bibliography in Appendix A.

K. MATHEMATICAL MATTER

The following practices will standardize the presentation of mathematical expressions in ESL Technical Reports.

Use typewriter composition for all mathematical expressions; use transfer sheets (rub-ons) for mathematical symbols and oversize print not available on the typewriter.

Display and set off from text all numbered equations and those unnumbered equations that should stand out.

Indent displayed equations at the double paragraph (10-space) indentation. Use triple paragraph indentations for continuations. This method is considerably less time-consuming than centering.

Number all displayed equations consecutively, beginning with (1), and enclose numbers in parentheses at the right-hand margin. Place the number on the same line of a single-line equation and on the last line of a multiple-line equation. For appendix equations, include corresponding letter designations with the number.

Punctuate all equations in running text and in display, according to their function in the sentence.

Parentheses, brackets, and integral and summation signs must be as high as the mathematical expressions they enclose.

Spacing--Put a space before and after mathematical signs (=, +, -, x, >, <, , etc.).

$$t_s = t - r/c$$

Exceptions to the rule follow.

1. Do not space around a mathematical sign in a superscript or subscript, or in the limits of the summation sign or integral sign.

$$e^{S_n(t-t')}$$

$$n = \sum_{n=1}^{\infty}$$

$$\int_{-\infty}^{\infty}$$

2. The minus sign in a negative quantity is set tight, except before a built-up fraction where the space is needed to separate the sign from the fraction dividing line.

$$G = -6 \qquad I = - \underline{4}$$

3. The plus-or-minus symbol is set tight when it qualifies a number and is spaced when it operates a number.

$$\text{an accuracy of } \underline{\pm 5} \text{ seconds} \qquad 10\% N \pm 2\%$$

Treat simple mathematical expressions in a sentence as part of the running text. Do not break up a simple equation such as $t > 0$ or an expression such as $\sinh x$ at the end of line. A sample of spacing of mathematical text follows.

Figure 2 shows a particle with charge q located outside a perfectly conducting cylinder tube with length and radius a . Let (z, \quad) be the induced charge density on the tube.

For $t > 0$ one deforms C into C_1 and C .

Simplify text equations; i.e., use an oblique line rather than a horizontal bar:

$$A/BC \text{ rather than } \frac{A}{\overline{BC}}$$

$$A/2) \cos x \text{ rather than } \frac{A}{2} \cos x$$

$$V_T/2 \text{ rather than } \frac{1}{2} V_T.$$

Arrangement--Arrange parentheses, brackets, and braces in an expanding order:

$$\left\{ \left[\left(\left\{ \left[(\quad) \right\} \right) \right] \right] \right\}$$

Place transitional words on a separate line at the left margin between equations.

Since $\sigma_y = (1/2) \rho v_i^2$

and $v_i = 2v_p$

therefore $\sigma_y = 2 \rho v_p^2$

Define all symbols used in equations; list definitions if numerous.

where

\bar{v} = average velocity

\bar{E} = amplitude of the EMP

T_e = electron energy (eV)

\bar{B} = magnetic field

If a report contains numerous symbols, repeat them in a list of symbols.

When necessary, divide long equations before a mathematical sign (=, +, -, etc.). Two examples follow:

$$\nabla \times \left(\frac{1}{u} \bar{B} \right) = \bar{J} = \sigma \bar{E} + \frac{\partial (\epsilon \bar{E})}{\partial t} \quad (1)$$

$$Q = A_2 \rho^1 \left(\frac{p_2}{p_1} \right)^{1-\gamma} \left\{ 2g p_1 v_1 \left(\frac{\gamma}{\gamma-1} \right) \left[1 - \left(\frac{p_2}{p_1} \right)^{\gamma-1/\gamma} \right] \right\}^{1/2}$$

$$= A_2 \left\{ 2g \frac{p_1}{v_1} \left(\frac{\gamma}{\gamma-1} \right) \left[\left(\frac{p_2}{p_1} \right)^{2/\gamma} - \left(\frac{p_2}{p_1} \right)^{\gamma-1/\gamma} \right] \right\}^{1/2} \quad (2)$$

Derivations of equations, methods of calculation and other support mathematical work will be placed in an appendix.

Frequently used standard mathematical signs and symbols (Table B-1) and the Greek alphabet (Table B-2) are presented here for quick reference.

TABLE B-1. MATHEMATICAL SIGNS AND SYMBOLS.

$=$	equal to	\propto	varies directly; is proportional to
\neq	not equal to	∇	DEL--gradient
\approx	approximately equal to	$\nabla \cdot$	DEL DOT--divergence
\sim	equivalent; similar	$\nabla \times$	DEL CROSS--curl
\equiv	identical with	\therefore	therefore
\neq	not identically equal	\because	since, because
∞	infinity	\dots	and so forth (in relation to sequence)
$::$	equal to, in proportion	$' \ " \ ''$	prime, double prime, triple prime
$<$	less than	$!$	factorial
$>$	greater than	$ \ $	absolute value of quantity within the bars
\leq	less than or equal to	\rightarrow	approaches the limit
\geq	greater than or equal to	\int	integral
\angle	angle	\sum	summation
\perp	perpendicular to	∂	partial differential
\parallel	parallel to	\lim	limits of
$\sqrt{\quad}$	radical, root		
\times or \bullet	multiplied by		
$:$ or $/$	ratio of, proportion		
\pm	plus or minus		

TABLE B-2. GREEK ALPHABET.

Identity	Lower Case	Capital	Samples of Handwritten Forms						
Alpha(a)	α	A	α	A	α	α	α	α	α
Beta(b)	β	B	β	β	β	β	β	β	β
Gamma(g)	γ	Γ	γ	γ	γ	γ	γ	γ	γ
Delta(d)	δ	Δ	δ	Δ	δ	δ	δ	δ	δ
Epsilon(e)	ε	Ε	ε	Ε	ε	ε	ε	ε	ε
Zeta(z)	ζ	Ζ	ζ	Ζ	ζ	ζ	ζ	ζ	ζ
Eta(h)	η	Η	η	Η	η	η	η	η	η
Theta(th)	θ, ϑ	Θ	θ	Θ	θ	θ	θ	θ	θ
Iota(i)	ι	Ι	ι	Ι	ι	ι	ι	ι	ι
Kappa(k)	κ	Κ	κ	Κ	κ	κ	κ	κ	κ
Lambda(l)	λ	Λ	λ	Λ	λ	λ	λ	λ	λ
Mu(m)	μ	Μ	μ	Μ	μ	μ	μ	μ	μ
Nu(n)	ν	Ν	ν	Ν	ν	ν	ν	ν	ν
Xi(x)	ξ	Ξ	ξ	Ξ	ξ	ξ	ξ	ξ	ξ
Omicron(o)	ο	Ο	ο	Ο	ο	ο	ο	ο	ο
Pi(p)	π	Π	π	Π	π	π	π	π	π
Rho(r)	ρ	Ρ	ρ	Ρ	ρ	ρ	ρ	ρ	ρ
Sigma(s)	σ	Σ	σ	Σ	σ	σ	σ	σ	σ
Tau(t)	τ	Τ	τ	Τ	τ	τ	τ	τ	τ
Upsilon(u)	υ	Υ	υ	Υ	υ	υ	υ	υ	υ
Phi(ph)	φ, ϕ	Φ	φ	Φ	φ	φ	φ	φ	φ
Chi(ch)	χ	Χ	χ	Χ	χ	χ	χ	χ	χ
Psi(ps)	ψ	Ψ	ψ	Ψ	ψ	ψ	ψ	ψ	ψ
Omega(o)	ω	Ω	ω	Ω	ω	ω	ω	ω	ω

Handwritten symbols and the letters which they closely resemble pose problems for editing and composing personnel. When submitting a draft report, make all mathematical expressions clear. Greek letters should be clearly designated by name in blue pencil in the margin; all symbols must be carefully written and checked; and the difference between capital and lower case letters clearly indicated. Confusion between zero and the letter "o," between the numeral "1" and the letter "l," between "alpha" and "a," and other expressions which resemble each other can be avoided if due care is exercised in writing and marking the copy. Subscripts and superscripts should be clearly indicated on the draft.

APPENDIX C

OPEN-ENDED WORD LIST

The following frequently used words and phrases have been found in varying combinations of inconsistent usage in ESL Technical Reports. Realizing that not all source books (including dictionaries) agree, we have attempted to provide standards for consistent use of these words or compounds.

This list is neither all-inclusive nor comprehensive. Space is left at the end of each alphabetical category for you to add your own problem words or phrases as they occur and as their usage is resolved.

Because the Government Printing Office Style Manual and Look It Up are the primary sources, this list is not always applicable to correspondence going through AFESC/DA but is limited to ESL Technical Reports. Two primary examples of divided opinion on word usage are:

Airbase: Dictionaries are divided. GPO says one word, but AFESC/DA and some other Air Force agencies say two words (air base). ESL style should be to use it as one word, except as part of an acronym such as ABSS (Air Base Survivability Systems) or when referring to a specific airbase. The reasons for this are fairly obvious.

Firefighting: Although Webster's says two words, GPO, the American Heritage Dictionary, and our AFESC/RD firefighters prefer one word. For our purposes, Webster's is overruled.

The following abbreviations are used with this word list to help you understand usage:

(n) Noun (v) Verb (a). Adjective (adv) Adverb
(pa) Predicate Adjective

A-flat
AFMs, AFRs, AFPS
AM-2 mat
a priori
about-face
above-cited
ad hoc
ad interim
ad valorem
ad-lib
adjacent (avoid)
aftereffect
air-condition
air-conditioned
air-cool (v)
air-cooled
air-cooled (a)
air-stripping (a)
airbase
airborne
airfreight
airlift
airport
airspace
airstrip
airtight
all clear
all-inclusive
amber-colored
amperemeter
amperehour
analyses
analyze, analysis
anti-Semitic
anti-inflation
antifreeze
antipenetration
areawide
asphalt concrete
authored (Do not use)
ax-grinding
axis, axes

B

bacillus, bacilli
backdate
backdrop
backfill
backlog
backwash
barbed wire
barrelful
baseboard
battlefield
beaverboard
beeline
beeswax
bell-like (a)
betweendecks
biannual
blast-induced (a)
blastoff
bolt-holes (n)
bomblet-field-clearing (n)
broad-spectrum (a)
broken down (pa)
broken-down (a)
bylaw
bypass
byproduct

calculator-assisted (a)
camera-ready (a)
carryall
carte blanche
caseload
catharsis, catharses
cement-stabilized (a)
centerline
checklist
checkpoint
cityscape
citywide
cleanup (n, a)
clearheaded
closed-load
co-op
co-owner
co-worker
coalfield
coalmine
coarse-grained (a)
coauthor
coaxial
coeditor
companywide
concrete-cutting (a)
consortium, consortia
cornmeal
cost-effective (a)
counteract
counterattack
counterclockwise
counterflow
counterforce
cross fire
cross-section(a)
cross-check
cross-country
cumulus, cumuli
curriculum, curricula
custom-built
custom-made
cutaway

D

darkroom
data base = (or database, but be consistent)
daybreak
daytime
de facto
de-emphasize
de-escalate
deadweight
decision-making (a)
deep-freeze
deep-sea
deepwater
degree-day
deice
desk-top (a)
deskbook
desktop
double-edged
doublecheck
downfield
downrange
downtime
downturn
drainpipe
drawstring
drumfire
dustcover
duty-free

E

ERdlator
earthquake
equation (-)
evenhanded
ever-present
ex officio
extra-large
extraterritorial
eyesore

F

Fahrenheit
face-saving
fadeaway
fallback
farmhouse
farseeing
farsighted
feedback
feedwater
fencepost
fiberboard
fiberglas®
fiberglass
field-tested (a)
field-test (v)
fieldwork
figurehead
finalize (avoid)
finite element
firefighter
firehouse
firetruck
first-pass (a)
firsthand
flagpole
flash point
flashlight
flatbed
flight crew
flight deck
flight line
flight plan
flip-flop
floodgate
floodlight
floodwall
floorboard
flowmeter
flow rate
flowchart
flowoff
flyaway
flyby
flyover
flywheel
foghorn
foldaway
foldout
followup
food chain

F

foolproof
footbrake
footcandle
footgear
footprint
foredeck
foregoing
foreground
fourfold
free-rolling (a)
freshwater
front-end (a)
full-scale
full-scale (a)
full-sized
fuse, fuze

G

gage (preferred)
gallon-per-day (a)
gas mask
gasbag
gateway
gatepost
germproof
glassblower
glassmaker
goodwill
greenhouse
grillwork
groundwater
guardrail
guesswork
guesthouse
guideline
guidepost
gunfire
gunpowder

H

half hour
half-done
half-life
half-truth
hallway
hand-held (a)
handbook
handful
handgrenade
handgun
handmade
handpick
hard-and-fast
hardback
hardhat
hardpan
hardware
hardwood
hazlenut
head-on
headgear
headphone
headwind
heat wave
heatstroke
helter-skelter
high-intensity (a)
high-pressure (a)
high-quality (a)
high-speed (a)
hillside
hollow-fiber (a)
homemade
hotline
houseguest

-ize (avoid when possible)
I-Beam
ice floe
ice pack
iceberg
ill-advised
in order to (avoid)
in regard to (avoid)
in terms of (avoid)
in-group
in-house
infighting
infrared
infrastructure
intrastate
irregardless (not acceptable)
it is (avoid)
its (possessive)

J

jerry-built
jobsite
jth
judge advocate
jump off (v)
jumpoff (n, a)
jumpsuit

K

Kevlar®
kitchenware
knee-deep
knee-high
kneehole
knock down (v)
knockdown (a, n)
kth
kudos (singular)

Logical Unit 4
laissez-faire
lakefront
lakeshore
land-grant
landmark
landmine
landslide
lawbook
lawn mower
lawsuit
layout
leapfrogged
left-hand
legwork
letter-perfect
levelheaded
life buoy
life-giving
lifelike
lift off (v)
liftoff
lightweight
like-minded
lime-stabilized
lineup (a, n)
loadcart (n, a, adv)
lock out (v)
locked-wheel (a)
lockout (a, n)
long-awaited
long-range
longboat
longstanding
looseleaf
low-flow (a)
low-pressure (a)
low-speed (a)
lowercase
lowlands

M

minicomputer
multiple-crater (a)
multicrater
mission-dependent (a)
Mk 83
macrocosm
microcomputer
mailbag
mainline
made-over (a)
man-day
man-hour
manmade
many-sided
mediumweight
medium-sized
most-favored-nation
multitudinous (avoid)

N

native-born(a)
 nerve-racking
 newsletter
 nighttime
 ninety-one
 no-wheel-braking
 non-DOD
 non-European
 nonexistent
 nonnuclear
 nonaligned
 nonconformist
 noncorrosive
 nondestructive
 non-self-sustaining
 northeast
 nose gear
 nosewheel
 nuts-and-bolts (a)

odd-shaped
off-the-shelf (a)
offbase
offbeat
oftentimes (avoid)
oilspill
old-line (a)
onceover
one-person (a)
one-shot (a)
ongoing
onsite
open-ended
openminded
out-of-date (a)
ovenbaked
over-the-counter (a)
overanxious

parenthesis, parentheses
parti-colored
parttime
partway
pasteup
patchwork
paucity (avoid)
pay-as-you-go (a)
payback
payload
pear-shaped
peephole
pennyweight
pennywise
per annum (avoid)
phase-in
phaseout
photo-offset
photoelectric
photophobic
pigeonholed
pipefitter
place-name
plug-in (a, n)
plume-rise (a)
pocket-size
point in time (avoid)
point-blank (a)
policy making (a)
polyelectrolyte-aided
Portland Cement (author's choice)
portland cement (author's choice)
post officer
post-orbit
postattack
postgraduate
pre-position (v)
preemployment
preprocessor
profit-sharing
programmed
proofreading
pseudo-Messiah
pseudo-official
pseudoped
puff-plume (a)

Q

quasi-autonomous
quayside
quick-freezing
quicklime
quid pro quo
quitclaim

radarscope
radioactive
radiogram
railway
rank-and-file (a)
ratepayer
re-collect (to collect again)
re-creation (to re-create)
re-cross-examination
re-form (reshape)
re-revise (avoid)
ready-made
recollect
reevaluate
reexamination
rent-a-car
right-hand (a)
roadbuilding
rock-bottom
round trip
roundup
rubber-stamped
run-through
runaround
rustproofing

Southeast Asia
Step 1
saddle-stitched
safed (v)
safeguarded
safing (n, a)
saltpeter
saltwater (a. n)
scattershot
seawater
seawater
second-class
second-degree
self-defense
self-destruct
self-starting
semi-infinite
semipermanent
serviceman
set up (v)
set-to
setscrew
setup (a, n)
shareholder
shipboard
shipyard
shoreline
shoreside
short circuit (n)
short-circuit (v)
short-term
shortcut
shortwave
sidelight
sideswipe
sidewalls
single-crater (a)
single-wheel (a)
singlehanded
site-specific
small-scale
smokeproof
snow-blind (a)
snowfall
snowstorm
spacecraft
spectroscope
speechmaking

splashdown
stabilized material base
standoff
standpoint
start up (v)
startup (a, n)
state-of-the-art (a)
steady-state
stem-winding
stone-lofting (a)
stonemason
stopwatch
straightedge
stress-dependent
subaverage
subbase
super eloquent
syllabus, syllabuses
symposium, symposia
synthesis, syntheses
systemwide

TOS, TRs, TMOs
tailgate
tailhook
take off (v)
takeoff (n, a)
terra firma
theobromine
there is (avoid)
thought-provoking
three-piece
three-ply
time-consuming
time-dependent
time-sharing
timekeeping
timesaving
tire-lofting (a)
top-drawer
topnotch
tow rope
towing-safed (a)
transshipment
troubleshooting
turnaround
two-way

U

ultra-high-frequency (a)
ultrasmooth
un-ionized
unaccompanied
underway
un-self-conscious
up-to-date (a)
utilize (avoid

V

VIP
V-necked
vasoconstriction
vertebra, vertebrae
vis a vis (do not use)
viz-a-viz (do not use)
vortex, vortexes

wage scale
waist-deep
waistline
walkie-talkie
warfighting
warhead
warmaking
wastewater
waterjet-assisted
water-resistant (a)
waterpower
waterproof
watershed
waterway
weatherbeaten
well-defined
wheel-braking
wheelbarrow
wheelbase
whisk broom
wide-awake
windspeed
windswept
wirecutting
workday
workload
workmanlike
workplace
writeoff (n)

X

x-ray
xerox®

Y

year-end
year-round
yours

zigzagging

NOTE: Some words and phrases are marked "avoid" or "do not use." This is because they are pretentious, vague in meaning, superfluous or over worked. For example, why use "in order to" when "to" will suffice or "utilize" when "use" will fit just as nicely within the context of the sentence. To say that these usages are customary in scientific and technical writing is not enough to justify them.

ACRONYMS

CBR - California Bearing Ratio

FOD - Foreign Object Damage

MOS - Minimum Operating Strip

FRP - Fiberglass - Reinforced Polyester

APPENDIX D

TECHNICAL REPORT CHECKLIST

This checklist can serve as a guide to ensure that your final camera ready copy can be processed for publication. It can also ensure that the technical editor will not have to return the report to you for major corrections before publication. The following administrative, technical, and editorial requirements should be met before CRC is submitted.

A. ADMINISTRATIVE

1. Complete DD Form 1473, including distribution statement, abstract and key words.
2. Completed R&D Form 16 (Technology Application Assessment) signed by project officer and division chief.
3. Preface signed by project officer and division chief.
4. Distribution list (to include AFESC/CC/CA/CV/ and HQs USAF/LEE).
5. Copyright permissions (if needed).
6. Coordination of monitoring agency (if needed).

B. TECHNICAL

1. Report should meet minimum requirements for technical accuracy and adequate coverage of subject matter.
2. Research documented in report should fulfill technical requirements of contract.
3. Report should contain a reasonable representation of findings, to include:
 - a. Introduction (Objective, Background, Scope)
 - b. Description of experiment, test or methodology
 - c. Results or observations

d. Conclusions

e. Recommendations (if any)

4. Objective listed in report should correlate with objective of research entered in Work Unit Summary (DD 1498) for the Job Order Number.

C. EDITORIAL

1. Printer's image. Text and illustrative material must fit within a 6 1/2- by 9-inch image.

2. Reproducible copy. Text, tables and illustrative material must be of sufficient quality for printing microfiche reproduction and reprinting from microfiche. In other words, approaching perfection.

3. Style. Material must be presented in organized, readable and consistent fashion.

D. FORMAT

1. Standard Outline Format.

Standard outline format should be followed as indicated below. Each section will be designated by a sequential upper case Roman Numeral and a short caption. The section designation will be centered on the first typing line of the page with the short caption centered on the page, two lines below the section designation line. The text will begin three lines below the caption. Section I and the first page of the first appendix will begin at the top of the first available full right-hand page following the front matter. All other sections may begin on either a left-or right-hand page. Sections, paragraphs, and subparagraphs will be prepared in the following format:

SECTION I

INTRODUCTION

A. FIRST HEADING

1. First Subheading

a. Second Subheading

(1) Third Subheading

2. Order of Presentation.

The following sequence should apply to all Technical Reports. Bear in mind that not all reports will have all of these elements.

<u>Front matter</u>	Front Cover (Required) Notice Page Report Documentation Page, DD Form 1473 (includes abstract) (Required) Summary Preface (Required) Table of Contents (Required) List of Figures (Required) List of Tables (Required) Glossary of Terms List of Abbreviations, Acronyms and Symbols
<u>Body of Report</u>	Introduction (Required) Main Text (Required) Conclusion (Required) Recommendations Appendices References Bibliography
Other	Distribution List (Limited Distribution) Back Cover (Unlimited Distribution) (Provided by Editor)

E. TIMETABLE

To assure that the technical report is published before the research is outdated, project officers must monitor every step of the effort. In addition to assuring that the research meets requirements and that it is finished on time, you must make sure that your technical report is published within a reasonable time after the effort is finished. AFSC directives say 6 months and this seems a reasonable interval if the time period is broken down in the following manner:

1. Contractor provides project officer with two copies of draft report within 45 days after completion of technical effort.

2. Project officer reviews one copy for technical accuracy and gives the other copy to technical editor for review. He forwards technical and editorial comments to contractor within 45 days of receipt.

3. Contractor provides final camera-ready copy, to include illustrations, within 30 days.

4. Project officer provides technical editor with signed final report within 30 days of receipt from contractor.

5. Final 30 days are allowed for proofreading, corrections, and Public Affairs coordination (if needed).

Note: With present printing procedures these reports (with pictures or foldouts or exceeding 25,000 total images) that cannot be printed locally will require 4-6 weeks for printing. In other words, most of our reports!

F. COPYRIGHTS

If copyright permission is necessary, this should be obtained while the report is in its draft stages.

G. RESPONSIBILITY FOR PUBLICATION

Although a few reports will be published by other agencies, the majority of TRs will be prepared and published by ESL. A good rule of thumb is that if 50 percent or more of the funding for a technical report is provided by AFESC/RD, ESL will prepare, edit and publish the report, even if published jointly with another laboratory. You must assure that the controlling agency is the publishing agency. This is required by AFESC Supplement 1 to AFSCR 80-20.

NOTE: Some material presented in this checklist duplicates that found within the Handbook. This was done intentionally so that you might reproduce this checklist at your convenience or to assist contractors in preparing camera-ready TRs.

APPENDIX E

PROOFREADER'S SYMBOLS

SYMBOL	Meaning	As typeset and marked for correction	Examples	Corrected
e	delete	data y that we have accumulated	e	data that we have accumulated
e	delete and close up	$A(x) \times B(x)$ is the term	e	$A(x)B(x)$ is the term
(close up	the product $A(x) \times B(x)$	(the product $A(x)B(x)$
...stet	restore words crossed out	it is not true	stet	it is not true
^	indicates where to make insertion	col ^l inear	l	collinear
⊙	insert a period	... in our experiment ⊙	⊙	... in our experiment.
⋈	insert a comma	However we ...	⋈	However, we ...
λ	insert a hyphen	un ^λ ionized	λ	un-ionized
^	type or insert as subscript	α_2, A^{λ}	α_2, A^{λ}	α_2, A^{λ}
∨	type or insert as superscript			
#	insert a space	1536 [#] A	#	1536 A
⁄	en dash	in the range 20 [⁄] 40 MeV	⁄	in the range 20–40 MeV
⁄	em dash	Relation (14) [⁄] and only relation (14) [⁄] can ...	⁄	Relation (14)–and only relation (14)–can ...
¶	start a new paragraph	¶ The state is represented by the Wheeler form of the vacuum functional. ¶ Besides the well-known ...	¶	The state is represented by the Wheeler form of the vacuum functional. Besides the well-known ...
no ¶	do not start a new paragraph		no ¶	
⌊	lower matter	$a + b = c + k \cdot p$	U/η	$a + b = c + k \cdot p$
⌋	raise matter			
⌈	move matter to left	$x + y = \boxed{z + w} \quad (15)$	$\boxed{z + w} =$	$x + y = z + w \quad (15)$
⌋	move matter to right			
lc	use lower-case letter	liquid-H ^{lc} container	lc	liquid-He container
cap	use capital letter	24.5 ^{cap} MeV	cap	24.5 MeV
sc	use small capital letter	Kr ^{sc} II	sc	Kr II
rom	use roman type	Next ^{rom} l measured ^{sc} l in MeV.	rom/ital	Next l measured l in MeV.
ital	use italic type			
tr	transpose	con ^{tr} ceive	tr	conceive
bf	make boldface roman	E × H	bf	E × H
bf ital	make boldface italic	E + H	bf ital	E + H
/	indicates order in which corrections are to be made in a line	parametrizati [/] on	[/] tr	parametrization

Figure E-1. Proofreader's Symbols.

ANNOTATED BIBLIOGRAPHY

The following bibliography is presented to help the beginning writer, editor, or project officer in establishing a meaningful reference library, covering various aspects of grammar, usage, and style. These references are divided into two categories: Essential and Nice to Have.

A. ESSENTIAL

1. Bernstein, Theodore M. The Careful Writer: A Modern Guide to English Usage, Antheneum Press, New York, 1965. A concise but thorough handbook, alphabetically arranged to cover questions of usage, grammar, punctuation, precision, and structure. Lively, entertaining, and instructive.

2. Chicago Manual of Style. University of Chicago Press, 13th Edition, Chicago, 1982. A standard style guide, particularly valuable for its guidance on hyphenation, latin terms, punctuation, and capitalization. The University of Chicago English Department is still among the best.

3. Day, Robert W. How to Write and Publish a Scientific Paper, ISI Press, 2nd Edition, Philadelphia, 1983. Primarily aimed at writing a scientific paper or magazine article, but the principles found in this book apply to technical report writing as well as to any kind of communicative writing.

4. Flesch, Rudolph, Look It Up, Harper and Row, New York, 1977. A handy desk guide to consistent style and usage, with tricky words arranged alphabetically. Better guidance than the dictionary on hyphenation.

5. MIL-STD-847B, Format Requirements for Scientific and Technical Reports. Prepared for or by the Department of Defense, November 1983. The basic guidance for organizing, writing, and preparing final TRs. All instructions in this MIL-STD apply, except as amended or expanded by this handbook.

6. Sabin, William A., Gregg Reference Manual, McGraw-Hill, New York, 5th Edition, 1977. A compact but comprehensive reference on modern business style, punctuation, capitalization, grammar, and usage. Up to date. Easy to use. Quotes rules and gives examples. The basic grammar textbook.

7. Strunk, William Jr. and White, E.B., The Elements of Style, McMillan, New York, 3rd Edition, 1979. The "Bible" for all writers. Not much more can be said about this small but important book.

8. U.S. Government Printing Office Style Manual. U.S. Government Printing Office, Washington, D.C., 1984. The primary guidance for the government writer on word compounding, abbreviations, capitalization, and technical style in using words and numerals. More up to date than most dictionaries.

9. Webster's Third International Dictionary, G. C. Merriam Company, Springfield Massachusetts, 1981. Comprehensive but bulky to use. Does not always agree with Government Style Manual on compounding of words but good as a backup source and for definitions. One must have a dictionary.

B. NICE TO HAVE

1. Bly, Robert W. and Blake, Gary, Technical Writing, Structure, Standards and Style. McGraw-Hill, New York, 1982. Small but excellent reference, combining practical guidance on rules, formats and standard usage.

2. Brusaw, Allred, and Olin, Handbook of Technical Writing, St. Martin's Press, New York. Material in this handbook is practical and user-oriented. For easy access, material is arranged alphabetically, but a topical key is used to give page references, according to broad subject categories, and a checklist to the writing process refers to key entries as they are needed in the writing sequence.

3. Ebbitt, Wilma R. and Ebbitt, David R., Writer's Guide and Index to English, 6th Edition, Scott-Foresman and Company, Dallas 1978. Part of a continuing revision of Porter Perrin's classic textbook. This somewhat bulky text is easy to use because of indexing of material.

4. Evans, Bergen and Evans, Linda, A Dictionary of Contemporary American Usage, Random House, New York, 1957. Almost 30 years old, this book is far-seeing and perceptive in its treatment of American English. For example, a superb treatment of "data is" vs "data are."

5. Fowler, H. W., A Dictionary of Modern English Usage, 2nd Edition, Oxford Press, London, 1966. Again, staidly conservative, but still good to settle arguments and to emphasize old-line usage.

6. Follett, Wilson, Modern American Usage, Grosset and Dunlap, New York, 1970. Traditional and conservative, still a good book to read when "nitpicking." Distinctions between "shall and will" and "who or whom" will always arise.

7. Hawley, Gessner R., Condensed Chemical Dictionary, 10th Edition, Van Nostrand-Rheinhold, New York, 1981. Of particular value in spelling and defining chemical terms and determining whether trade names are involved.

8. Kilpatrick, James J., The Writer's Art, Andrews, McMeel and Parker, Kansas City, 1984. A witty, incisive commentary on writing and usage, primarily from the journalist's view, but applicable to all writing.

9. Shaw, Harry, Punctuate it Right, Barnes and Noble, New York, 1963. A concise guide to punctuation.

10. Stafford, Alison K., and Culpepper, Billie Jean, The Science-Engineering Secretary, Prentice-Hall, New Jersey, 1965. Out of print, otherwise it would be on the essential list.

11. Words Into Type, 3rd Edition, Prentice-Hall, New Jersey, 1974. Another style manual for the printed word. Although similar to GPO and Chicago Style Manual it has more material on photographs and typography

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